



CARLO GAVAZZI SPACE SpA

ACOP

Doc. Type: Specification

DRD N°: ENG-01

Doc. N°: ACP-SP-CGS-001

Issue: 1

Date: Jan. 2005

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Title: ACOP INTERFACE SPECIFICATION (ICD)

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<b>CHANGE RECORD</b>			
<i>ISSUE</i>	<i>DATE</i>	<i>CHANGE AUTHORITY</i>	<i>REASON FOR CHANGE AND AFFECTED SECTIONS</i>
1	January 2005	-	First Issue



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## 1. SCOPE OF THE DOCUMENT

This document includes two main sections:

- Interface Specification
- Interface Control

The Interface Specification section describes the requirements for external interfaces (i.e. between the payload and the carrier) and internal interfaces between payload subsystems (e.g. ACOP Core and ERLS).

The Interface Control section describes the design (e.g. interface drawings) of the various interfaces which comply with the interface requirements.

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## 2. DOCUMENTS

### 2.1 APPLICABLE DOCUMENTS

AD	Doc. Number	Issue / Date	Rev.	Title / Applicability
1	SSP 52000-IDD-ERP	D / 6.08.03		EXpedite the PROcessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document
2	NSTS/ISS 13830	C / 01.12.1996		Implementation Procedures for Payloads System Safety Requirements – For Payloads Using the STS & ISS.
3	JSC 26493	17.02.1995		Guidelines for the preparation of payload flight safety data packages and hazard reports.
4	SSP 50004	April 1994		Ground Support Equipment Design requirements
5	SSP-52000-PDS	March 1999	B	Payload Data Set Blank Book
6	SSP 52000-EIA-ERP	Feb. 2001	A	Express Rack Integration Agreement blank book for Express Rack payload
7	GD-PL-CGS-001	3 / 17.03.99		PRODUCT ASSURANCE & RAMS PLAN
8	SSP 52000-PAH-ERP	Nov. 1997		Payload Accommodation Handbook for EXPRESS Rack
9	SSP 50184	D / Feb. 1996		Physical Media, Physical Signalling & link-level Protocol Specification for ensuring Interoperability of High Rate Data Link Stations on the International Space Program
10	SSP 52050	D / 08.06.01		S/W Interface Control Document for ISPR ***ONLY FOR HRDL, SECTION 3.4 ***
11	ECSS-E-40	A / April 1999	13	Software Engineering Standard
12	AMS02-CAT-ICD-R04	29.08.2003	04	AMS02 Command and Telemetry Interface Control document. Section AMS-ACOP Interfaces
13	SSP 52000-PVP-ERP	Sept. 18, 2002	D	Generic Payload Verification Plan EXPedite the PROcessing of Experiments to Space Station (EXPRESS) Rack Payloads
14	NSTS 1700.7B	Rev. B Change Packet 8 / 22.08.00		Safety Policy and Requirements for Payloads using the STS
15	NSTS 1700.7B Addendum	Rev. B Change Packet 1 01.09.00		Safety Policy and Requirements for Payloads using the International Space Station
16	SSP 52005	Dec. 10, 1998		Payload Flight equipment requirements and guidelines for safety critical structures
17	NSTS 18798B	Change Packet 7 10.00		Interpretation of NSTS Payload Safety Requirements
18	MSFC-HDBK-527	15.11.86	E	Materials selection list for space hardware systems Materials selection list data
19	GD-PL-CGS-002	1/ 12.02.99		CADM Plan
20	GD-PL-CGS-004	2 / 07.04.03		SW Product Assurance Plan
21	GD-PL-CGS-005	2 / 09.05.03		SW CADM Plan

Table 2-1 Applicable Documents

 CARLO GAVAZZI SPACE SpA	<h1>ACOP</h1>	Doc N°: <b>ACP-SP-CGS-001</b> Issue: <b>1</b> Date: <b>Jan. 2005</b>
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## 2.2 REFERENCE DOCUMENTS

RD	Doc. Number	Issue / Date	Rev.	Title
1	GPQ-MAN-02	1		Commercial, Aviation and Military (CAM) Equipment Evaluation Guidelines for ISS Payloads Use
2	BSSC (96)2	1 / May 96		Guide to applying the ESA software engineering standards to small software projects
3	GPQ-MAN-01	2 / Dec. 98		Documentation Standard for ESA Microgravity Projects
4	MS-ESA-RQ-108	1 / 28 Sep. 2000		Documentation Requirements For Small And Medium Sized MSM Projects
5	PSS-05			Software Engineering Standards
6	GPQ-010	1 / May 95	A	Product Assurance Requirements for ESA Microgravity Payload. Including CN 01.
7	GPQ-010-PSA-101	1		Safety and Material Requirements for ESA Microgravity Payloads
8	GPQ-010-PSA-102	1		Reliability and Maintainability for ESA Microgravity Facilities (ISSA). Including CN 01

*Table 2-2 Reference Documents*

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### 3. DEFINITIONS AND ACRONYMS

#### A

AAA	Avionics Air Assembly
ABCL	As-Built Configuration data List
ACOP	AMS-02 Crew Operation Post
ACOP-SW	ACOP Flight Software
ADP	Acceptance Data Package
AMS-02	Alpha Magnetic Spectrometer 02
APS	Automatic Payload Switch
AR	Acceptance Review
ASI	Agenzia Spaziale Italiana ( <i>Italian Space Agency</i> )
ATP	Authorization To Proceed

#### B

BC	Bus Coupler
BDC	Baseline Data Collection
BDCM	Baseline Data Collection Model

#### C

CAD	Computer Aided Design
CCB	Configuration Control Board
CCSDS	Consultative Committee on Space Data Standards (standard format for data transmission)
C&DH	Command & Data Handling
CDR	Critical Design Review
CGS	Carlo Gavazzi Space
CI	Configuration Item
CIDL	Configuration Item data List
CM	Configuration Management
COTS	Commercial Off The Shelf
cPCI	CompactPCI (Euro Card sized standard interface to the PCI)
CSCI	Computer Software Configuration Item
CSIST	Chung Shan Institute of Science and Technology

#### D

DCL	Declared Components List
DIL	Deliverable Items List
DIO	Digital Input / Output
DML	Declared Materials List
DMPL	Declared Mechanical Parts List
DPL	Declared Processes List
DRB	Delivery Review Board
DRD	Document Requirements Description

#### E

EEE	Electrical, Electronic & Electromechanical
EGSE	Electrical Ground Support Equipment
EM	Engineering Model
ER	EXPRESS Rack
ERL	EXPRESS Rack Laptop
ERLC	EXPRESS Rack Laptop Computer
ERLS	EXPRESS Rack Laptop Software
EMC	Electro-Magnetic Compatibility
ESA	European Space Agency
EXPRESS	EXpedite the PRocessing of Experiments to Space Station

#### F

FEM	Finite Element Model
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FFMAR      Final Flight Model Acceptance Review  
FLASH      Rewriteable persistent computer memory  
FM          Flight Model  
FMECA      Failure Modes, Effects & Criticalities Analysis  
FPGA      Field Programmable Gate Array  
FSM          Flight Spare Model

## G

GIDEP      Government Industry Data Exchange Program  
GSE          Ground Support Equipment

## H

HCOR      HRDL Communications Outage Recorder  
HD          Hard Drive  
HDD          Hard Disk Drive  
HRDL      High Rate Data Link  
HRFM      High Rate Frame Multiplexer  
HW          Hardware

## I

ICD          Interface Control Document  
I/F          Interface  
IRD          Interface Requirements Document  
ISPR      International Space-station Payload Rack  
ISS          International Space Station

## J

JSC          Johnson Space Center

## K

KIP          Key Inspection Point  
KSC          Kennedy Space Center  
KU-Band    High rate space to ground radio link

## L

LAN          Local Area Network  
LCD          Liquid Crystal Display  
LFM          Low Fidelity Model  
LRDL      Low Rate Data Link

## M

MDL          Mid-Deck Locker  
MGSE      Mechanical Ground Support Equipment  
MIP          Mandatory Inspection Point  
MMI          Man Machine Interface  
MPLM      Multi-Purpose Logistic Module  
MRDL      Medium Rate Data Link

## N

NA          Not Applicable  
NASA      National Aeronautics and Space Administration  
NCR          Non Conformance Report  
NDI          Non Destructive Inspection  
NRB          Non-conformance Review Board  
NSTS      National Space Transportation System (Shuttle)

## O

OLED      Organic Light-Emitting Diode

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ORU      Orbital Replacement Unit

## P

PA      Product Assurance  
PCB      Printed Circuit Board  
PCI      Peripheral Component Interconnect (personal computer bus)  
PCS      Personal Computer System  
PDR      Preliminary Design Review  
PEHB      Payload Ethernet Hub Bridge  
PEHG      Payload Ethernet Hub Gateway  
PFMAR      Preliminary Flight Model Acceptance Review  
PLMDM      Payload Multiplexer De-Multiplexer  
PMC      PCI (Peripheral Component Interconnect) Mezzanine Card  
PMP      Parts, Materials & Processes  
PROM      Programmable Read Only Memory  
PS      Power Supply

## Q

QM      Qualification Model

## R

RFA      Request For Approval  
RFD      Request For Deviation  
RFW      Request For Waiver  
RIC      Rack Interface Controller  
ROD      Review Of Design  
ROM      Read Only Memory  
RX      Reception

## S

SATA      Serial Advanced Transfer Architecture (disk interface)  
S-Band      Space to ground radio link  
SBC      Single Board Computer  
SC MDM      Station Control Multiplexer De-Multiplexer  
ScS      Suitcase Simulator  
SDD      Solid-state Disk Drive  
SIM      Similarity Assessment  
SIO      Serial Input Output  
SOW      Statement Of Work  
SPF      Single Point Failure  
SRD      Software Requirements Document  
STS      Space Transportation System (Shuttle)  
SW      Software

## T

TBC      To Be Confirmed  
TBD      To Be Defined  
TBDCM      Training & Baseline Data Collection Model  
TBDCMAR      TBDCM Acceptance Review  
TBP      To Be Provided  
TCP/IP      Transmission Control Protocol / Internet Protocol  
TFT      Thin Film Transistor  
TM      Telemetry  
TRB      Test Review Board  
TRR      Test Readiness Review  
TRM      Training Model  
TX      Transmission

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# U

UIP       Utility Interface Panel  
UMA       Universal Mating Assembly  
USB       Universal Serial Bus

# #

100bt     Ethernet 100Mbit Specification  
1553     Reliable serial communications bus

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## 4. GENERAL DESCRIPTION OF ACOP

ACOP is a reliable special purpose computer to be launched to the International Space Station (ISS) to assist the operations of large science experiment projects. ACOP provides these services:

1. On-orbit recording mechanism for large volumes of data at high rates
2. Play back for downlink of the recorded data at high rates
3. A crew interface for complex experiments
4. General computing facilities
5. Alternate bi-directional commanding path via the HRDL interface

ACOP will initially support a state-of-the-art particle physics detector experiment Alpha Magnetic Spectrometer (AMS-02), which uses the unique environment of space to study the properties and origin of cosmic particles and nuclei including antimatter and dark matter, to study the actual origin of the universe and potentially to discover antimatter stars and galaxies.

After the AMS-02 experiment, ACOP will stay permanently in the US module as the only computer for large science experiment projects on the International Space Station for astronaut crew's use for recording and management of science data, monitoring and control of experiment, as well as improving the data communication between the earth and the space station.

In addition to the ACOP system there will be stowage bag sent to ISS that will contain additional hard drives that can be exchanged with the hard drives in ACOP. From time to time the astronauts will perform this exchange enabling ACOP to record all of AMS-02's data onto fresh hard drives. Once recorded, data will not be overwritten; rather they will be transported to ground as a permanent archive.

### 4.1 FUNCTION AND PURPOSE OF ACOP

ACOP must meet the following requirements of the AMS-02 program:

1. Operate effectively in the ISS space environment.
2. Create an on-orbit recording of all AMS-02 science data on removable<sup>1</sup> media - explicitly hard drives, preferably SATA based.
3. Provide not less than 20 days of recording capacity without crew intervention (based on 2Mbit/second rates), longer would be better.
4. Provide not less than 120 days of recording media capacity within a single mid deck locker equivalent storage unit, longer would be better.
5. Recorded data is an archive. Disks must be provided for the entire 3+ year mission without overwriting (a total of ~23 TByte)<sup>2</sup>.
6. For recording ACOP must support an orbital average data rate of not less than 4Mbit/second with bursts of up to 20 Mbit/second.
7. Provide a continuous operations display of ad hoc AMS-02 data for the ISS crew to monitor<sup>3</sup>.
8. Provide a continuous means for the ISS crew to issue ad hoc predefined commands without external equipment<sup>4</sup>.

<sup>1</sup> Hot swap software not required but performing a hardware hot swap must not permanently damage the system

<sup>2</sup> The current contract ASI N. I/044/04/0 foresees the provision of 14 nominal hard drives plus 2 hard drives as spare parts. The individual hard disk capacity is 200 – 250 GB (TBC).

<sup>3</sup> The design presented in this document foresees the presence of a LCD monitor, not foreseen in the contract ASI N. I/044/04/0

<sup>4</sup> The design presented in this document foresees the presence of a LCD monitor, not foreseen in the contract ASI N. I/044/04/0

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9. Provide, as needed, an exhaustive diagnostic, monitoring and operations environment via the EXPRESS laptop computer.
10. Support the playback of recorded data to ground systems at selectable data rates up to at least 20Mbits/second sustained while simultaneously recording at prescribed rates.
11. Support ACOP to AMS-02 commanding at selectable data rates up to at least 20Mbits/second sustained (No requirement for simultaneous recording or playback operations at higher rates.)
12. Support an alternate AMS-02 ground commanding and housekeeping report path via the HRDL interface.
13. CompactPCI based. Preferably 6U form factor.
14. Crew serviceable for upgrades and repairs - hardware and software.
15. Provide for upgrades and expansion to ACOP using COTS subsystems.
16. Provide support of ISS system upgrades (100bt MRDL follow on systems)<sup>5</sup>.
17. ACOP will be housed in an EXPRESS Rack Locker.
18. The mass budget for ACOP is 35.5 kg for the EXPRESS Rack Locker and 35.5 kg for the soft stowage bag.
19. The power allocated to ACOP is 200 watts<sup>6</sup>

## 4.2 UTILIZATION CONCEPT

The following are the key points of the ACOP operational concept as it pertains to the AMS-02 mission:

- ACOP is principally a ground operated payload.
- ACOP is powered and active whenever AMS-02 is active. Only short (<8hrs) outages.
- ACOP maintains an active bi-directional connection via the HRDL interface to AMS-02 at all times.
- The AMS-02 TX connection may be tee'd by the APS to the HRFM/KU for direct downlink.
- ACOP provides the mechanism for the crew to monitor and control AMS-02. Both front panel and ERL based interfaces are supported.
- As KU access is available, ACOP will be commanded to use its additional TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec).
- All data transmitted by AMS-02 is recorded onto ACOP's hard drives as a master copy of the AMS-02 science data.
- When ACOP has acknowledged that the data is recorded, AMS-02 can release that data from its buffers.
- The four hard drives installed in ACOP provide an estimated 20 days of recording (Note: Dependent on event rate and size.)
- The four installed hard drives will require periodic replacement by the ISS crew from the onboard stock of empty drives (30 minute operation about every 20 days)
- A batch of 20 hard drives provides 150 days of recording capacity.
- New batches of hard drives will be delivered by STS and the original master copies of the AMS-02 data will be returned to earth by STS.

<sup>5</sup> Not foreseen in the contract ASI N. I/044/04/0

<sup>6</sup> See the ACOP Design Report for the actual power budget

## 5. INTERFACE SPECIFICATION

### 5.1 ISS AVIONICS ARCHITECTURE

The ACOP System main element is the ACOP Core (simply ACOP in the following parts of this document), that is the box including all the ACOP specific elements with the corresponding interfaces. ACOP will be accommodated in a MDL/ISS locker inside a standard 8/2 EXPRESS Rack.

During the transport phase from ground to the ISS ACOP will be un-powered and without any active electrical connections.

Once installed on orbit, ACOP will be interfaced with the standard elements present in the EXPRESS Rack for payload management and in particular with the ER Laptop Computer, which will be used for controlling all the ACOP functions by means of a dedicated ER Laptop Software.

The following figure shows the ISS Command & Data Handling (C&DH) of the ACOP and AMS-02 system:

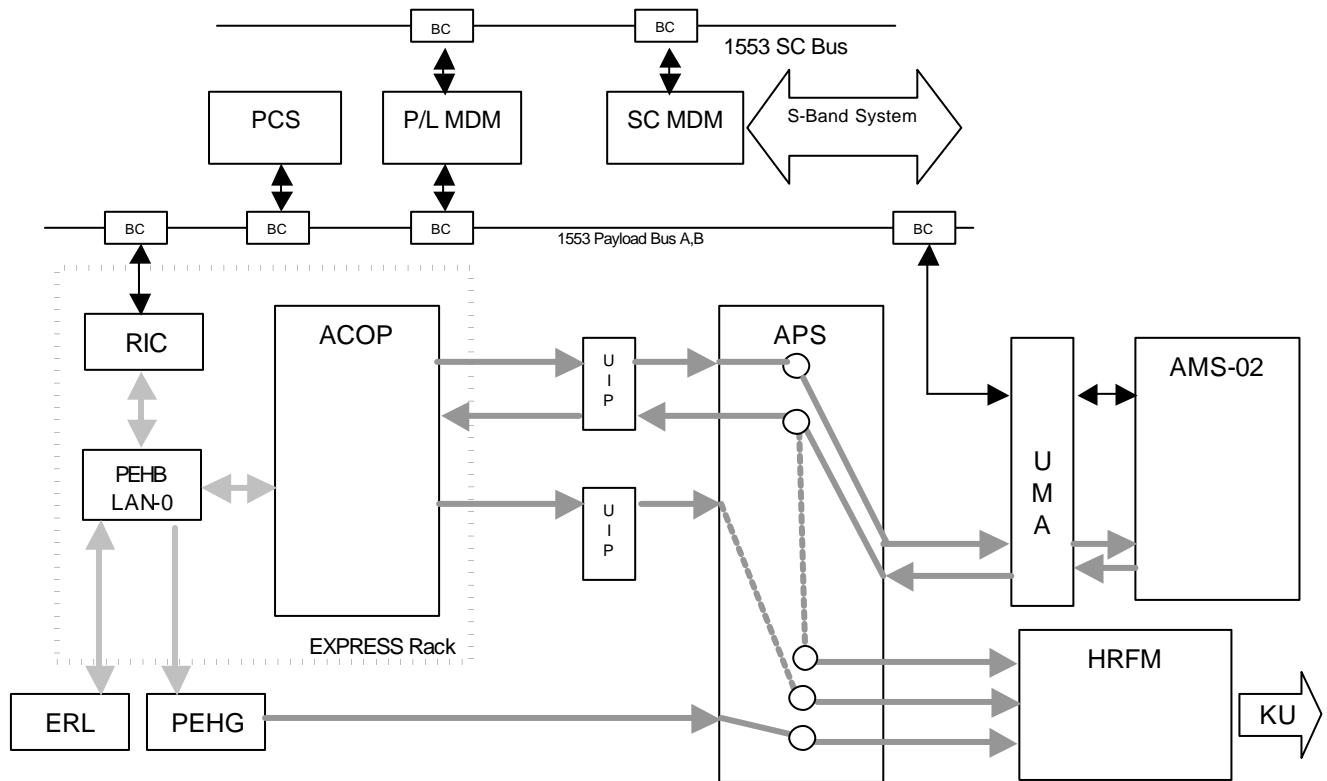


Figure 5-1 ACOP Electrical Interfaces with EXPRESS Rack, US Lab and AMS-02

Commanding and housekeeping data for ACOP is handled via the EXPRESS Rack Interface Controller (RIC). ACOP communicates with the RIC software on an Ethernet connection via the Payload Ethernet Hub Bridge (PEHB) using the Transmission Control Protocol/Internet Protocol (TCP/IP).

All ISS HRDL fibers are connected to the Automated Payload Switch (APS). This device provides cross bar switching among the fiber systems of ISS. ACOP has two prime targets for HRDL transfers. The first is the High Rate Frame Multiplexer (HRFM - via the High-Rate Communications Outage Recorder (HCOR)). The HRFM interleaves data to the KU-Band transmission system for downlink. The second target is the AMS-02 payload. The APS can be configured to tee data transmitted by AMS-02 to both the HRFM and ACOP.

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ACOP maintains an active bi-directional connection via the HRDL interface to AMS-02 at all times. As KU access is available, ACOP will be commanded to use its additional TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec). All data transmitted by AMS-02 is recorded onto ACOP's hard drives as a master copy of the AMS-02 science data. When ACOP has acknowledged that the data is recorded, AMS-02 can release that data from its buffers.

## 5.2 ACOP AVIONICS ARCHITECTURE

The ACOP System is based on CompactPCI systems. It contains a single board computer and several interface boards (including HRDL fiber interfaces, Ethernet interfaces, two USB interfaces to upgrade the operating system and programs and digital input-output and video interfaces). ACOP will also contain four exchangeable hard disks used to archive the data and the necessary interfaces. Other parts of ACOP are a LCD screen (TBC) and a simple push button interface, connected via peripheral cards.

In the main chassis and front panel there are the electrical parts which include a set of digital computer hardware and software. The functional block diagram of electrical parts is shown as Figure 5-2.

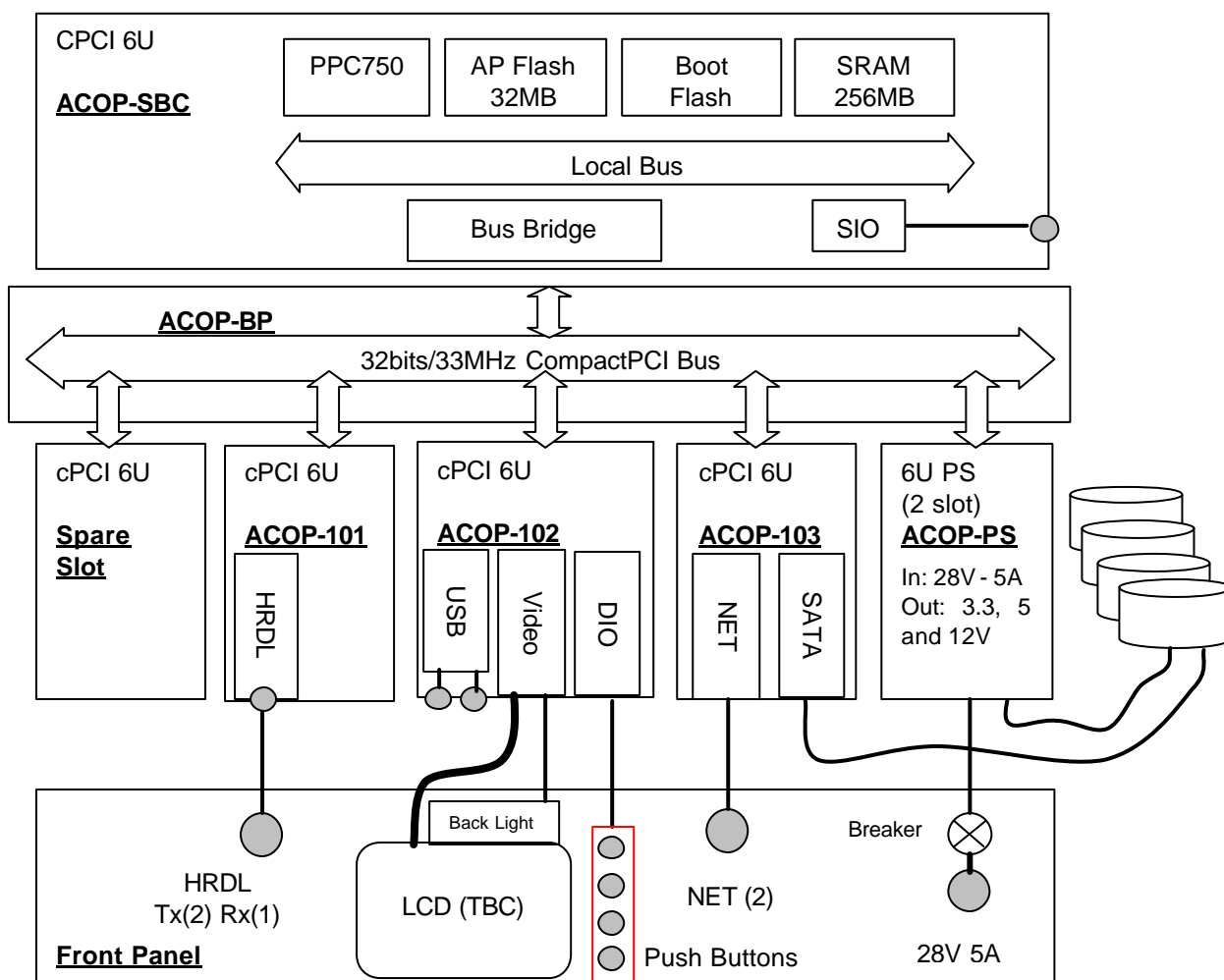


Figure 5-2 ACOP Electrical Block Diagram

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The ACOP chassis includes the following modules:

- ACOP-SBC: Single board computer, based on the IBM PPC 750, which provides 400Mhz speed as well as standard CompactPCI bus interfaces and acts as CompactPCI system slot.
- ACOP-T101: Provides 2 fiber optic TX and 1 fiber optic RX interfaces.
- ACOP-T102: Provides video output interface (TBC), 2 USB 1.1 interfaces and a DIO interface.
- ACOP-T103: Provides 2 Ethernet ports and 4 SATA ports.
- Spare Slot: for future expansion purpose
- ACOP-PS: Double height power supply.
- 4 hot swappable HDD (Hard Disk Drive)

The ACOP front panel will be equipped with:

- Four Momentary Push Buttons
- One Circuit Breaker with On/Off Switch
- One HRDL Connector
- One Power Connector
- One MRDL Connector with 10/100 base Ethernet
- One LCD screen with backlight (TBC)

During the engineering development stage, the I/O configuration will be tailored with PMC mezzanine modules and all modules integrated in an industry standard CompactPCI backplane. The design is scaleable and expandable, with a clear and built-in path for technology upgrades and insertion. A well-defined avionics Application Programming Architecture abstracts the application software from the underlying hardware, affording system evolution to ever-increasing performance standards, while effectively managing obsolescence. The Ethernet interface and USB interface can also supports software development and system maintenance during development.

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## 5.3 INTERFACE DEFINITION AND REQUIREMENTS

This Section defines the interfaces available on ACOP and describes the corresponding applicable requirements. Each type of interface is considered with a dedicated sub-section.

Main sources of the requirements are AD1, AD9 (specific for HRDL interface), AD10 Section 3.4 (specific for HRDL interface) and ACOP program specific requirements.

### 5.3.1 ELECTRICAL INTERFACES

#### 5.3.1.1 POWER INTERFACE

ACOP uses the standard 28Vdc power supply provided by the EXPRESS Rack, connected via the connections available on the EXPRESS Rack standard upper or lower connector panel and the corresponding standard connector on the ACOP Front Panel.

The maximum power allocated for ACOP is 200W.

The requirements applicable to this interface are given by AD1, Section 6 (Electrical Power Interfaces), Section 7.6 (Power Circuit Isolation and Grounding) and Section 8 (Electrical Wiring Interface)

#### 5.3.1.2 ETHERNET

The Ethernet link is used for the communications of ACOP with RIC and ER Laptop Computer (via PEHB). Also the Ethernet connection is provided by means of the connectors available on the EXPRESS Rack standard upper or lower connector panel and the corresponding standard connector on the ACOP Front Panel.

The information transmitted on the Ethernet includes:

- From ACOP:
  - ACOP House Keeping and Health & Status data
  - AMS-02 House Keeping and Health & Status data
  - AMS Science Data packets
- To ACOP:
  - Tele-commands for ACOP
  - Tele-commands to be routed to AMS-02

The requirements applicable to this interface are given by AD1, Section 7.7 (Signal Isolation and Grounding Requirements) and Section 9.2 (Ethernet Communications)

#### 5.3.1.3 HIGH RATE DATA LINK

The fiber-optic High Rate Data Link interfaces allow all the communications (Commands, House Keeping and Health & Status Data, Science Data) between ACOP and AMS-02. Two TX channels and one RX channel are used.

Since this interface is not a standard provision for the ER payloads, a dedicated connector on the ACOP Front Panel is used.

The requirements applicable to this interface are given by AD9, Section 3 (Performance Requirements) and AD10 Section 3.4

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#### 5.3.1.4 RS-422

A serial RS-422 link is available for ground tests and debugging. This interface is not used in nominal conditions for communications between ACOP and ER Laptop Computer on-orbit and the corresponding connector is not available on the ACOP Front Panel, but it is accessible only when the movable part of the ACOP Front Panel is open.

This interface shall be compliant with the RS-422 standard.

#### 5.3.1.5 UNIVERSAL SERIAL BUS

The USB 1.1 interface is present for allowing quick ACOP software upgrade without using the standard ISS resources. This interface is not used in nominal conditions and the corresponding connector is not available on the ACOP Front Panel, but it is accessible only when the movable part of the ACOP Front Panel is open

This interface shall be compliant with the Universal Serial Bus Specification Revision 1.1.

#### 5.3.1.6 DISCRETE COMMANDS (PUSH BUTTONS)

The main ACOP functions can be controlled by the ISS crew by means of 4 Push Buttons available on the ACOP Front Side. These buttons allow the ISS crew to issue predefined commands without external equipment and without using the ER Laptop Computer.

The design of this interface shall be compliant with the requirements given by AD1, Section 12.6 (Controls and Displays).

#### 5.3.1.7 LIQUID CRYSTAL DISPLAY (TBC)

This visual interface present on the ACOP Front Side (TBC) allows the ISS crew to be informed about the main ACOP parameters, without need of using the MMI available via the EXPRESS Rack Laptop computer. The continuous monitoring provided by this interface includes, as a minimum, the essential Health and Status flags of ACOP (i.e. power supply status, internal temperatures, available space on the memory units)

In particular, the following data could be displayed according to the AMS-02 program needs (TBC):

- ACOP House Keeping and Health & Status data
- AMS-02 House Keeping and Health & Status data
- AMS Science Data packets contents (TBC). These data will be displayed in rough format (no elaboration performed by ACOP)

Data to be actually displayed at a given time shall be selected by means of the push buttons available on the ACOP Front Panel.

The LCD shall be clearly visible when exposed to the illumination levels specified by AD1, Section 10.2 (Illumination Requirements – Lighting Design). The design of this interface shall be compliant with the requirements given by AD1, Section 12.6 (Controls and Displays).

Moreover, the LCD shall have as a minimum the following characteristics (TBC):

- 6 inch color display (TFT technology, at least 65,536 colors)
- Backlight
- Adjustable brightness
- VGA compatible (640 X 480)

	<h1 style="text-align: center;">ACOP</h1>	<i>Doc N°:</i> <b>ACP-SP-CGS-001</b>  <i>Issue:</i> <b>1</b> <i>Date:</i> <b>Jan. 2005</b>
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## 5.3.2 MECHANICAL INTERFACES

ACOP will be accommodated in a MDL/ISS locker inside a standard 8/2 EXPRESS Rack. Payload waste heat will be dissipated by means of the Avionics Air Assembly loop. No water cooling is foreseen.

The electrical and control interfaces between ACOP and the EXPRESS Rack / ISS crew shall be available on the ACOP customized Front Panel (power and data connectors, push buttons, etc.).

The requirements regarding the mechanical interfaces (including the interface with the EXPRESS Rack Avionics Air Assembly for cooling) are given by AD1, Section 3 (Physical and Mechanical Interfaces), Section 5 (Thermal/Fluids Interface) and Section 12 (Human Factors Interface Requirements)

## 5.3.3 ACOP SOFTWARE INTERFACES

The ACOP Software Interfaces manage:

- All the information flow between ACOP and EXPRESS Rack via PEHB and RIC, including ACOP House Keeping and Health & Status data, AMS-02 House Keeping and Health & Status data, AMS Science Data packets, Tele-commands for ACOP and Tele-commands to be routed to AMS-02.

The requirements applicable to this interface are given by AD1, Section 11 (Laptop Computers and Software) and by ACOP Software Requirement Document (ACP-SQ-CGS-001)

- All the information flow between ACOP and AMS-02, including Commands, House Keeping and Health & Status Data, Science Data packets.

The requirements applicable to this interface are given by ACOP Software Requirement Document (ACP-SQ-CGS-001)

## 5.4 INTERFACE VERIFICATION

The verification methods (test, analysis, inspection, review of design), the test plan and any special verification requirement necessary to ensure that the applicable interface requirements stated in Section 5.3 are satisfied shall be specified in the ACOP Verification Plan.

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## 6. INTERFACE CONTROL

### 6.1 ELECTRICAL INTERFACES

#### 6.1.1 POWER INTERFACE

ACOP is supplied by the +28Vdc standard power feeder provided by the EXPRESS Rack. A circuit breaker with a switch mounted on the front panel provides the On/Off switching capability. The circuit breaker is used also to protect wirings and downstream circuits from thermal damage that occurs during an over-current situation and as the first step of defense against electrical hazards. Circuit breaker's features include fail-safe operation, ambient temperature compensation and load protection function.

Main characteristics of the Power Interface are:

- The power requirement will be compliant to AD1 Section 6 (Electrical Power Interfaces).
- ACOP will not be powered during STS transportation.
- On ISS, ACOP will be powered from the ER upper or lower connector panel. A cable, with connectors meeting AD1 Section 6.6 (Electrical Connectors) and Section 8 (Electrical Wiring Interface), will be provided to link the ACOP's Front Panel power connector to the ER connector panel.
- ACOP power request is < 200Watt<sup>7</sup>.
- ACOP input power line is isolated from the structure by at least 1 Mohm with a parallel capacitance of <= 10uF, measured at the ACOP interface connector contacts, according to AD1 Section 7.6 (Power Circuit Isolation and Grounding)<sup>8</sup>.
- 24Vdc to 32Vdc (nominal 28Vdc) input voltage from the power cable
- Double-pole circuit breaker with over-current protection, on/off switch and reset inserted in series downstream the ACOP power connector.

Table 6-1 summarizes the ACOP Power Connector characteristics (the standard connector foreseen for the MDL payloads is used).

<sup>7</sup> See the ACOP Design Report for the actual power budget

<sup>8</sup> See Section 6.1.8 for details

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Connector Identification	Pin	Rtn Pin	Signal / Line Name	EMC Type	Voltage [V]	Current [mA]	Remarks
<b>Power Connector</b>  Circular Male Connector 4 pins  PART NUMBER: NB0E14-4PNT	A	C	+28V Power	HO	28	< 5000	Voltage = 24Vdc to 32Vdc
	B	-	Not Used	-	-	-	
	C	A	28V Return	HO	0	< 5000	Return line
	D	-	Ground	-	-	-	Used for bonding

*Table 6-1 ACOP Power Connector Characteristics*

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## 6.1.2 ETHERNET

The Ethernet link (Medium Rate Data Link) is used for the communications of ACOP with RIC and ER Laptop Computer (via PEHB). Two IEEE802.3 10/100Base Ethernet ports will be available. The information transmitted on the Ethernet includes:

- From ACOP:
  - ACOP House Keeping and Health & Status data
  - AMS-02 House Keeping and Health & Status data
  - AMS Science Data packets
- To ACOP:
  - Tele-commands for ACOP
  - Tele-commands to be routed to AMS-02

The Ethernet interfaces meet the requirements of AD1 Section 7.7 (Signal Isolation and Grounding Requirements) and Section 9.2 (Ethernet Communications). They provide EXPRESS Rack protocol to communicate to the RIC.

On ISS, the Ethernet connection will be provided by means of the ER upper or lower connector panel. A cable, with connectors meeting AD1 Section 9, will be provided to link the ACOP's Front Panel MRDL connector to the ER connector panel.

Table 6-2 summarizes the ACOP MRDL Connector characteristics (the standard connector foreseen for the MDL payloads is used, but the pin function has been customized to connect the second Ethernet interface - TBC).



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Connector Identification	Pin	Rtn Pin	Signal / Line Name	EMC Type	Voltage [V]	Current [mA]	Remarks
<b>MRDL Connector</b> (sheet 1 of 2)  Circular Male Connector 37 pins  PART NUMBER: MS27468T15F35P	1	2	Reserved for signal not used by ACOP	-	-	-	
	2	1	Reserved for signal not used by ACOP	-	-	-	
	3	-	Spare	-	-	-	
	4	5	Reserved for signal not used by ACOP	-	-	-	
	5	4	Reserved for signal not used by ACOP	-	-	-	
	6	7	Reserved for signal not used by ACOP	-	-	-	
	7	6	Reserved for signal not used by ACOP	-	-	-	
	8	9	Reserved for signal not used by ACOP	-	-	-	
	9	8	Reserved for signal not used by ACOP	-	-	-	
	10	11	Reserved for signal not used by ACOP	-	-	-	
	11	10	Reserved for signal not used by ACOP	-	-	-	
	12	13	Reserved for signal not used by ACOP	-	-	-	
	13	12	Reserved for signal not used by ACOP	-	-	-	
	14	15	Ethernet TX (+) OUT	RF	TBD	TBD	
	15	14	Ethernet TX (-) OUT	RF	TBD	TBD	
	16	17	Ethernet RX (+) IN	RF	TBD	TBD	
	17	16	Ethernet RX (-) IN	RF	TBD	TBD	
	18	-	Spare	-	-	-	

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Connector Identification	Pin	Rtn Pin	Signal / Line Name	EMC Type	Voltage [V]	Current [mA]	Remarks
<b>MRDL Connector</b> <b>(sheet 2 of 2)</b>  Circular Male Connector 37 pins  PART NUMBER: MS27468T15F35P	19	20	Ethernet 2 TX (+) OUT	RF	TBD	TBD	TBC
	20	19	Ethernet 2 TX (-) OUT	RF	TBD	TBD	TBC
	21	22	Ethernet 2 RX (+) IN	RF	TBD	TBD	TBC
	22	21	Ethernet 2 RX (-) IN	RF	TBD	TBD	TBC
	23	-	Spare	-	-	-	
	24	25	Reserved for signal not used by ACOP	-	-	-	
	25	24	Reserved for signal not used by ACOP	-	-	-	
	26	27	Reserved for signal not used by ACOP	-	-	-	
	27	26	Reserved for signal not used by ACOP	-	-	-	
	28	-	Spare	-	-	-	
	29	30	Reserved for signal not used by ACOP	-	-	-	
	30	29	Reserved for signal not used by ACOP	-	-	-	
	31	32	Reserved for signal not used by ACOP	-	-	-	
	32	31	Reserved for signal not used by ACOP	-	-	-	
	33	-	Spare	-	-	-	
	34	35	Reserved for signal not used by ACOP	-	-	-	
	35	34	Reserved for signal not used by ACOP	-	-	-	
	36	37	Reserved for signal not used by ACOP	-	-	-	
	37	36	Reserved for signal not used by ACOP	-	-	-	

Table 6-2 ACOP MRDL Connector Characteristics

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### 6.1.3 HIGH RATE DATA LINK

The fiber-optic High Rate Data Link interfaces allow all the communications (Commands, House Keeping and Health & Status Data, Science Data) between ACOP and AMS-02. Since this interface is not a standard provision for the ER payloads, a dedicated connector on the ACOP Front Panel will be used (TBD).

The HRDL Interfaces meet the requirements of AD9 Section 3 and AD10 Section 3.4.

Two TX channels and one RX channel are used:

- HRDL connections are a special resource required for ACOP that usually are not available for a standard EXPRESS Rack payload.
- Full time – (1) TX and (1) RX fiber are used for a AMS-02 to ACOP private payload network to support the complex data management required.
- Intermittent – (1) TX fiber is used to downlink AMS-02 telemetry data.
- (2) TX and (1) RX HRDL fibers on the UIP could be available during the AMS-02 mission: TX and RX under TESS (complete mission) and TX under MELFI (as initiation location, may have to move).  
To connect the HRDL channels, optical fiber cables will be installed inside the laboratory from ACOP to these J7 connectors, following a defined path agreed between EPIM and AMS-02 Program.

### 6.1.4 RS-422

A serial RS-422 link is available on the ACOP-SBC Card Front Panel for ground tests and debugging. This interface is not used in nominal conditions for communications between ACOP and ER Laptop Computer on-orbit and the corresponding connector is not available on the ACOP Front Panel, but it is accessible only when the movable part of the ACOP Front Panel is open (TBC).

This interface is compliant with the RS-422 standard.

### 6.1.5 UNIVERSAL SERIAL BUS

Two USB 1.1 interfaces (TBC) are present on the ACOP-T102 Card Front Panel for allowing quick ACOP software upgrade without using the standard ISS resources. These interfaces are not used in nominal conditions and the corresponding connectors are not available on the ACOP Front Panel, but they are accessible only when the movable part of the ACOP Front Panel is open (TBC).

This interface is compliant with the Universal Serial Bus Specification Revision 1.1 (1.5Mb/s)

### 6.1.6 DISCRETE COMMANDS (PUSH BUTTONS)

Four Push Buttons available on the ACOP Front Side allow the ISS crew to control the main ACOP functions by issuing predefined commands without external equipment and without using the ER Laptop Computer.

The design of this interface is compliant with the requirements given by AD1, Section 12.6 (Controls and Displays).

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## 6.1.7 LIQUID CRYSTAL DISPLAY (TBC)

A Color Active Matrix Liquid Crystal Display (LCD) with an integral Cold Cathode Fluorescent Lamp (CCFL) backlight system is mounted on the ACOP front panel (TBC).

This TFT-LCD has a 6.4 inch diagonally measured active display area with VGA resolution (640 vertical by 480 horizontal pixel array). Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arranged in vertical stripes.

A DC/AC inverter is installed inside to provide power for backlight tubes. Backlight tube brightness is adjustable by means of push buttons and software.

This visual interface present on the ACOP Front Side (TBC) allows the ISS crew to be informed about the main ACOP parameters, without need of using the MMI available via the ER Laptop Computer.

The continuous monitoring provided by this interface includes, according to the AMS-02 program needs (TBC):

- ACOP House Keeping and Health & Status data (i.e. power supply status, internal temperatures, available space on the memory units)
- AMS-02 House Keeping and Health & Status data
- AMS Science Data packets contents (TBC). These data will be displayed in rough format (no elaboration performed by ACOP)

Data to be actually displayed at a given time are selected by means of the Push Buttons available on the ACOP Front Panel.

The LCD will be clearly visible when exposed to the illumination levels specified by AD1, Section 10.2 (Illumination Requirements – Lighting Design) and the design of this interface is compliant with the requirements given by AD1, Section 12.6 (Controls and Displays).

The main characteristics of the LCD module are (TBC):

- Compatible with VGA-480, VGA-400, VGA-350 and free format.
- Screen size 6.4"
- Display format 640 x R,G,B x 480
- Display colors: 262,144
- Vertical frequency: ~ 60Hz
- Active area/Outline area = 62.3%
- Backlight brightness adjustable

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## 6.1.8 GROUNDING / BONDING / ISOLATION

The ACOP electronics is housed in an aluminium box (AL 7075). The parts of the box are electrically connected together in order to offer a low impedance path, therefore the mechanical box will operate as a shield against the internally generated emissions and the externally generated emissions.

An internal to the ACOP Front Panel bonding strap will connect the movable part of the ACOP Front Panel to the fixed part (the bonding between the two parts of the ACOP Front Panel will not rely only on the friction hinge)

The ACOP internal power lines are derived from the 28Vdc input line. The ACOP avionics, with respect to the overall grounding system, shall be based on the following concepts:

- The primary electrical power shall be isolated from ACOP chassis by a minimum of 1 Mohm (this applies to the alive and return line), in parallel with a capacitance less than 10uF, according to AD1 Section 7.6 (Power Circuit Isolation and Grounding).
- Implementation of a galvanic isolation between the primary power bus and all the secondary internal or distributed powers (greater than 1 Mohm)
- All the secondary power references shall be connected together and to the ACOP structure in a single point represented by an internal bonding stud.
- The metallic shells of all the ACOP external electrical connectors shall be electrically bonded to the ACOP bulkhead mount connector or the ACOP front panel case, with a DC resistance of less than 2.5 milliohms per joint.
- The Ethernet connection with the EXPRESS Rack RIC will be as per AD1 Section 7.7 (Signal Isolation and Grounding Requirements) for isolation and grounding.
- The HRDL interfaces will use optic fiber cables as physical layer, therefore there will not be electrical connections.
- One RS 422 Interface will be present only for ground test (TBC).
- Two USB 1.1 (TBC) ports will be present to be used by crew in non-nominal scenarios (SW patches) to connect portable devices (USB keys)

The primary payload bond path for ACOP shall be through the EXPRESS Rack-to-payload power connector interface (pin D, see Figure 6-1). The ACOP bonding class is R ( Radio Frequency Bond-RF).

Nevertheless a bonding stud will be implemented on the ACOP Front Panel to allow the single point connection of the internal secondary power references (internal side of the ACOP Front Panel) and eventually to connect an external bonding strap between ACOP and the EXPRESS Rack (external side of the front panel).

In Figure 6-1 the ACOP grounding philosophy is shown.



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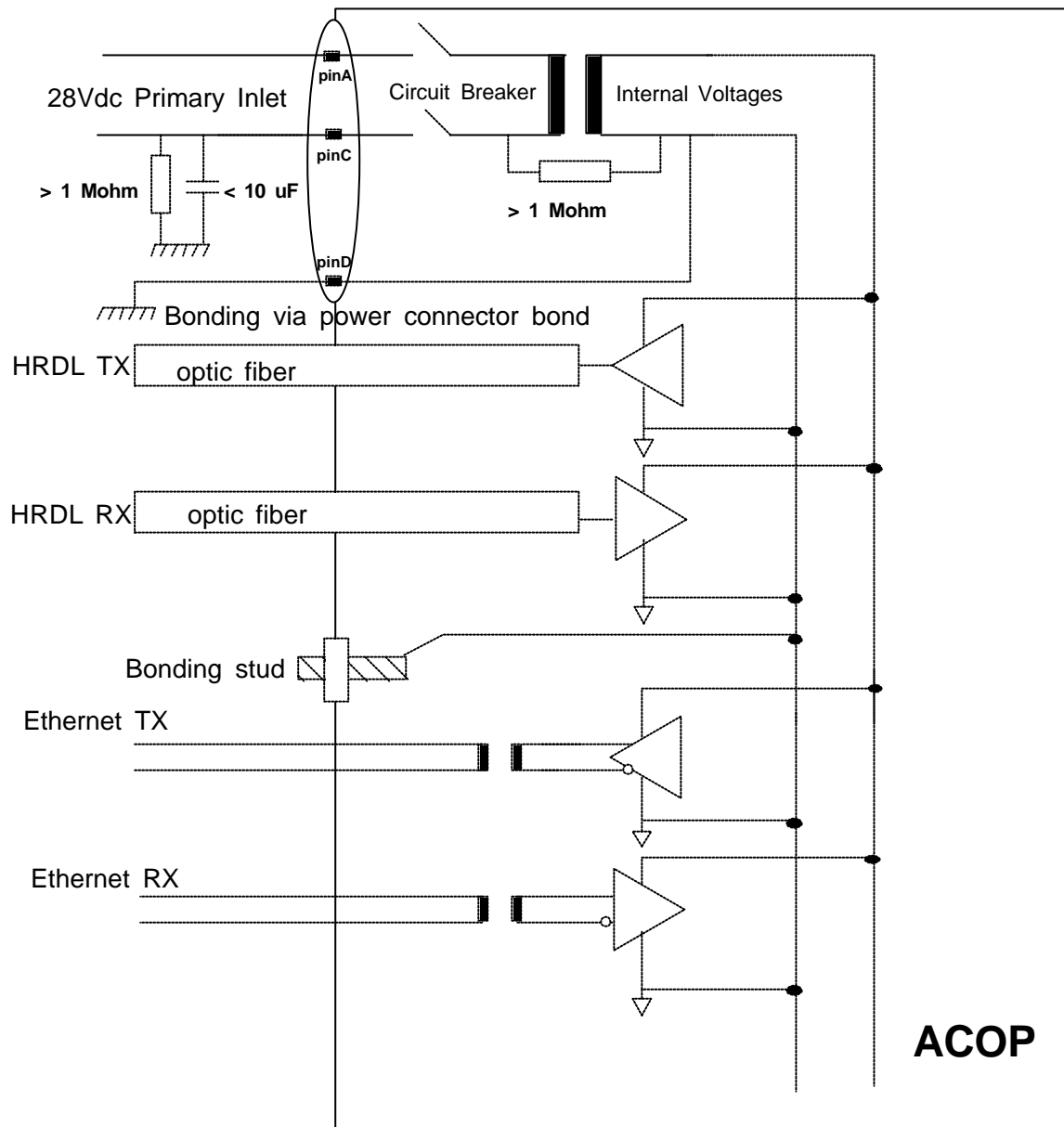


Figure 6-1 ACOP Grounding Philosophy

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## 6.2 MECHANICAL INTERFACES

ACOP will be accommodated in a MDL/ISS locker inside a standard 8/2 EXPRESS Rack. Payload waste heat will be dissipated by means of the Avionics Air Assembly loop: no water cooling is foreseen.

The ACOP locker dimensions are compliant with the standard MDL (as reported in AD1), customisation is applied only on the ACOP Front Panel. The overall dimensions are reported in the following figures (see the ACOP Design Report for more details on the ACOP mechanics).

The electrical and control interfaces between ACOP and the EXPRESS Rack / ISS crew are available on the ACOP customized Front Panel (power and data connectors, push buttons, etc.) shown in Figure 6-2 and Figure 6-3.

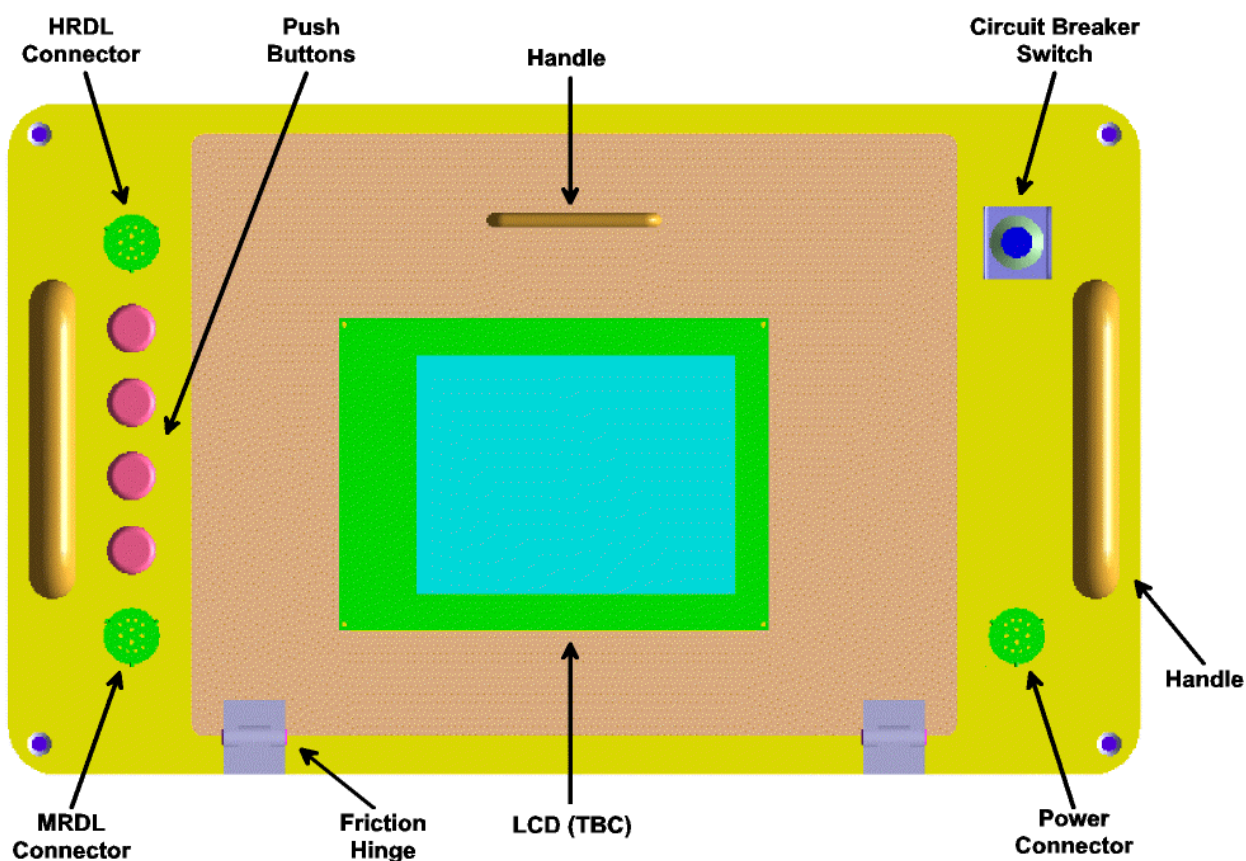


Figure 6-2 ACOP Customized Front Panel

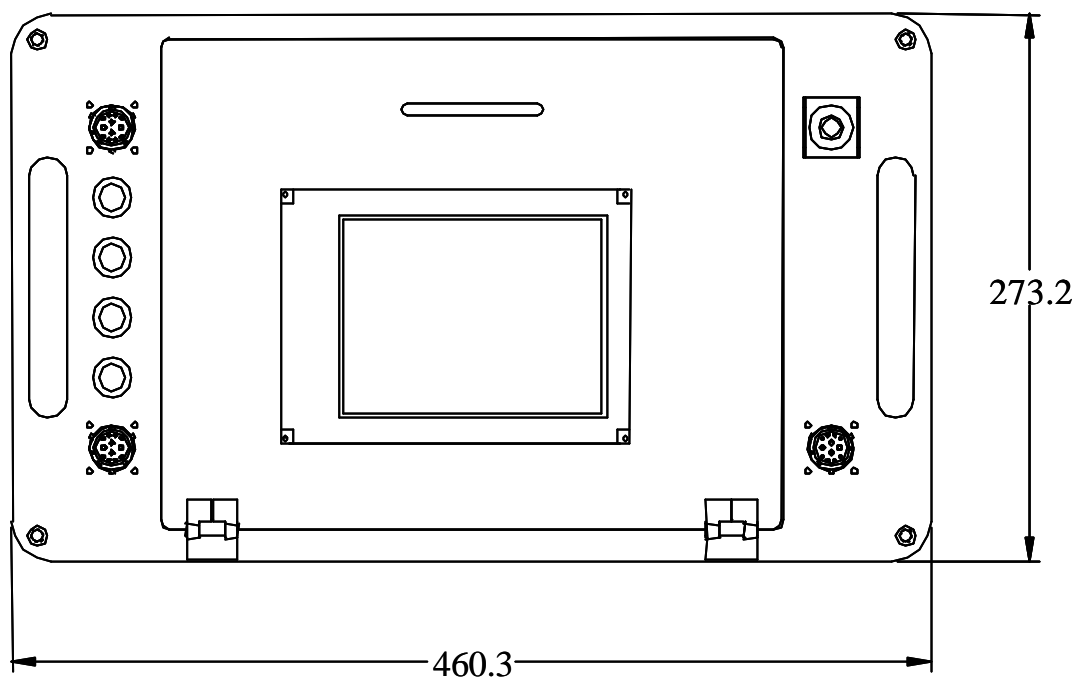


Figure 6-3 ACOP Customized Front Panel (dimensions)

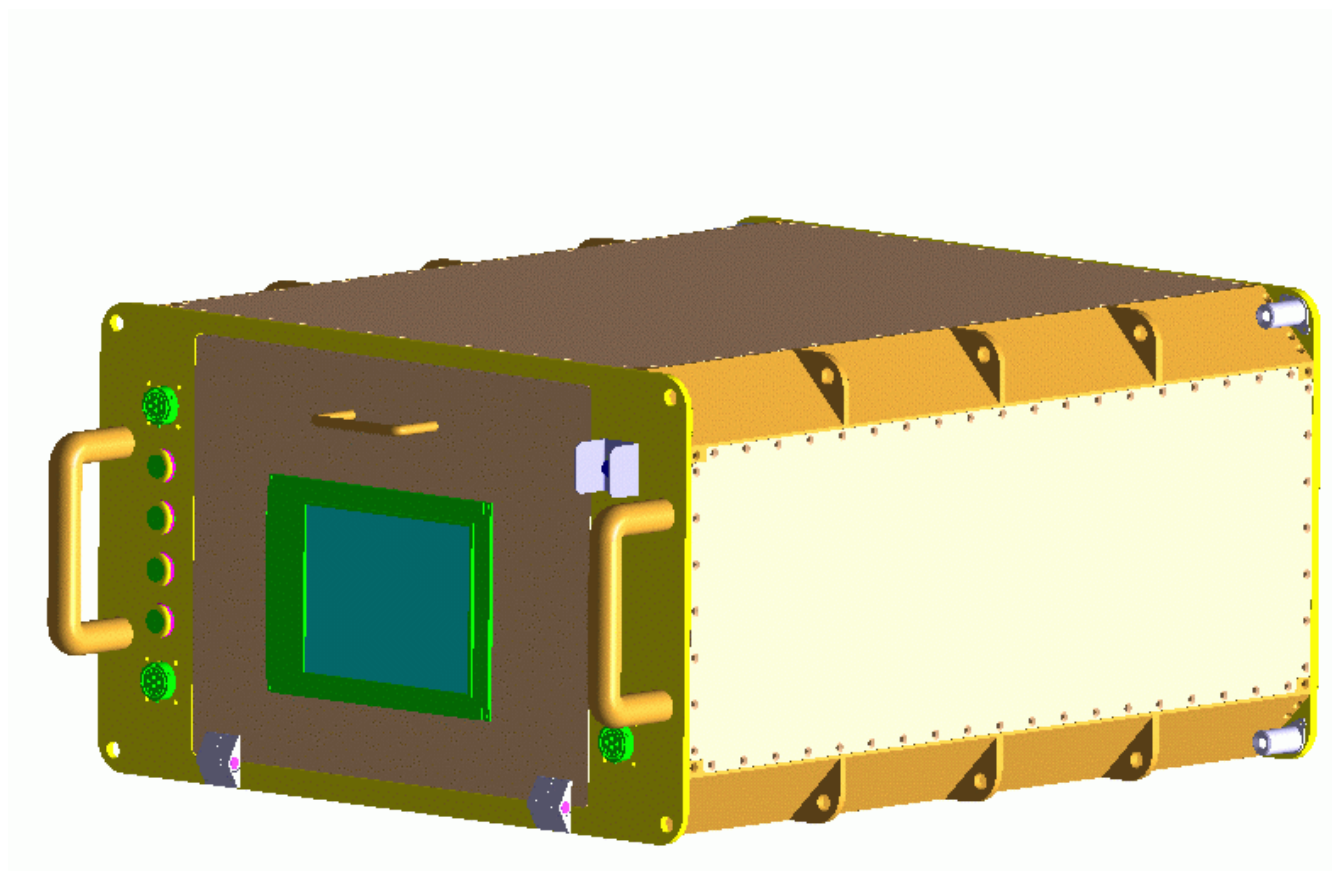


Figure 6-4 3D View of ACOP with the Front Panel Closed



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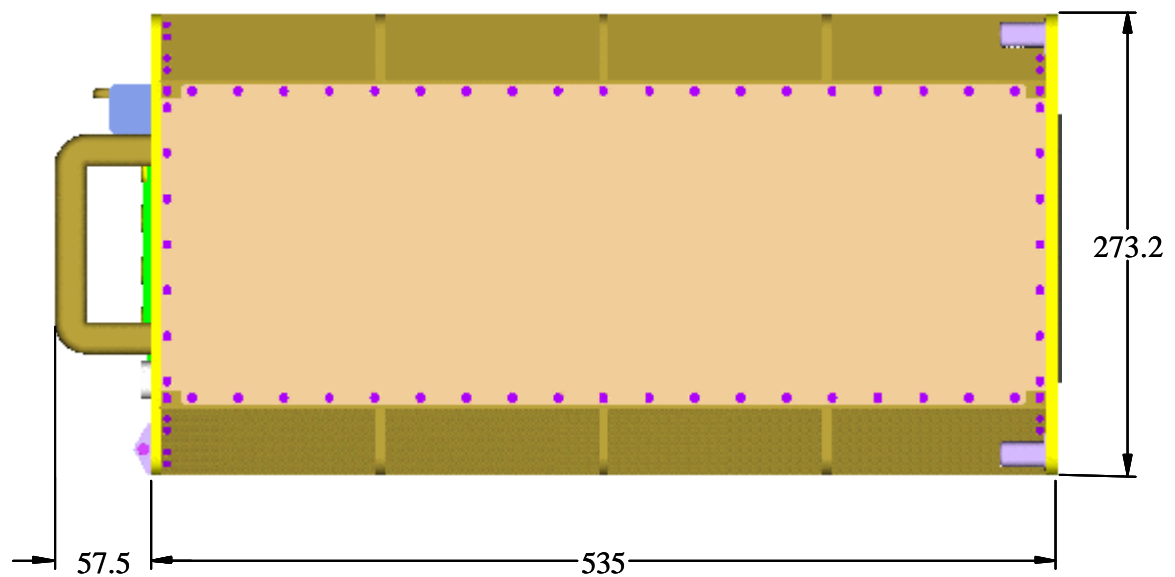
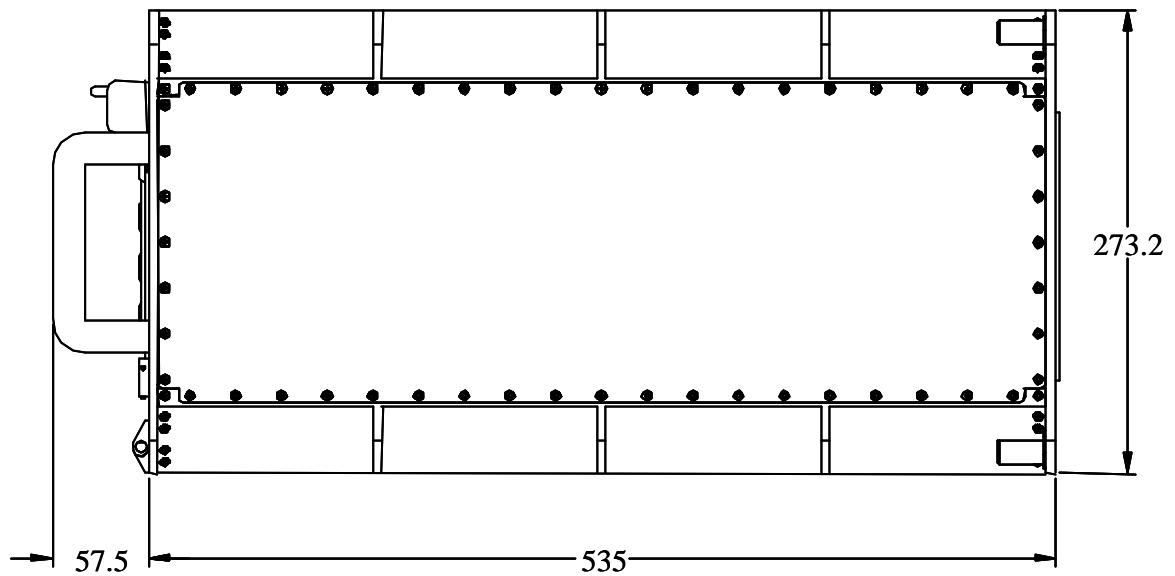


Figure 6-5 Side View of ACOP with the Front Panel Closed (dimensions)



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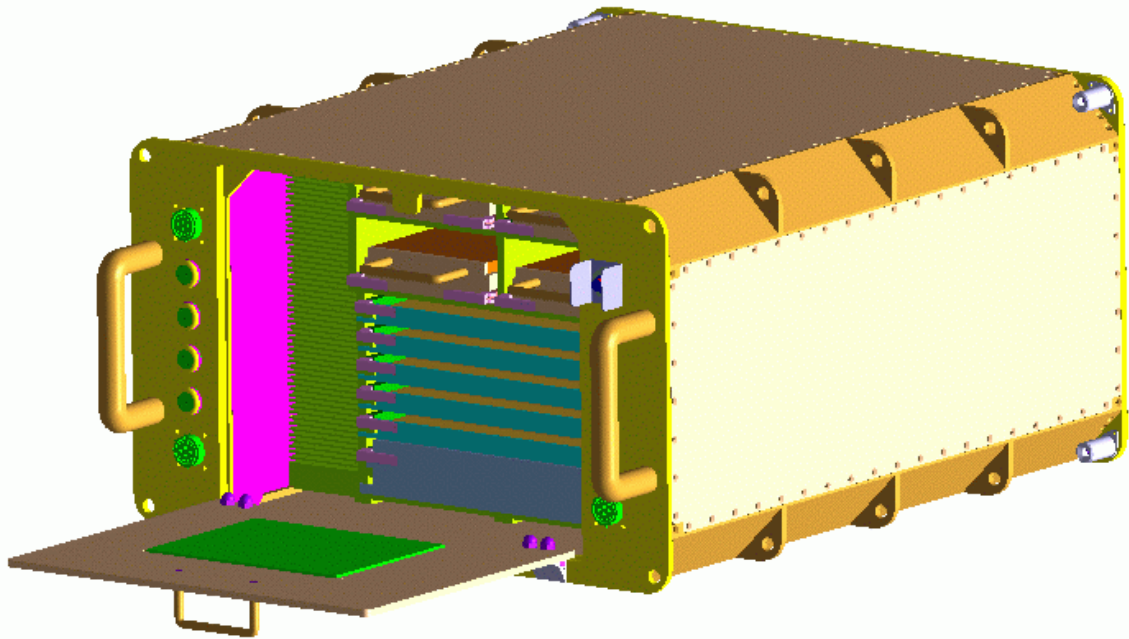
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*Figure 6-6 3D View of ACOP with the Front Panel Open*

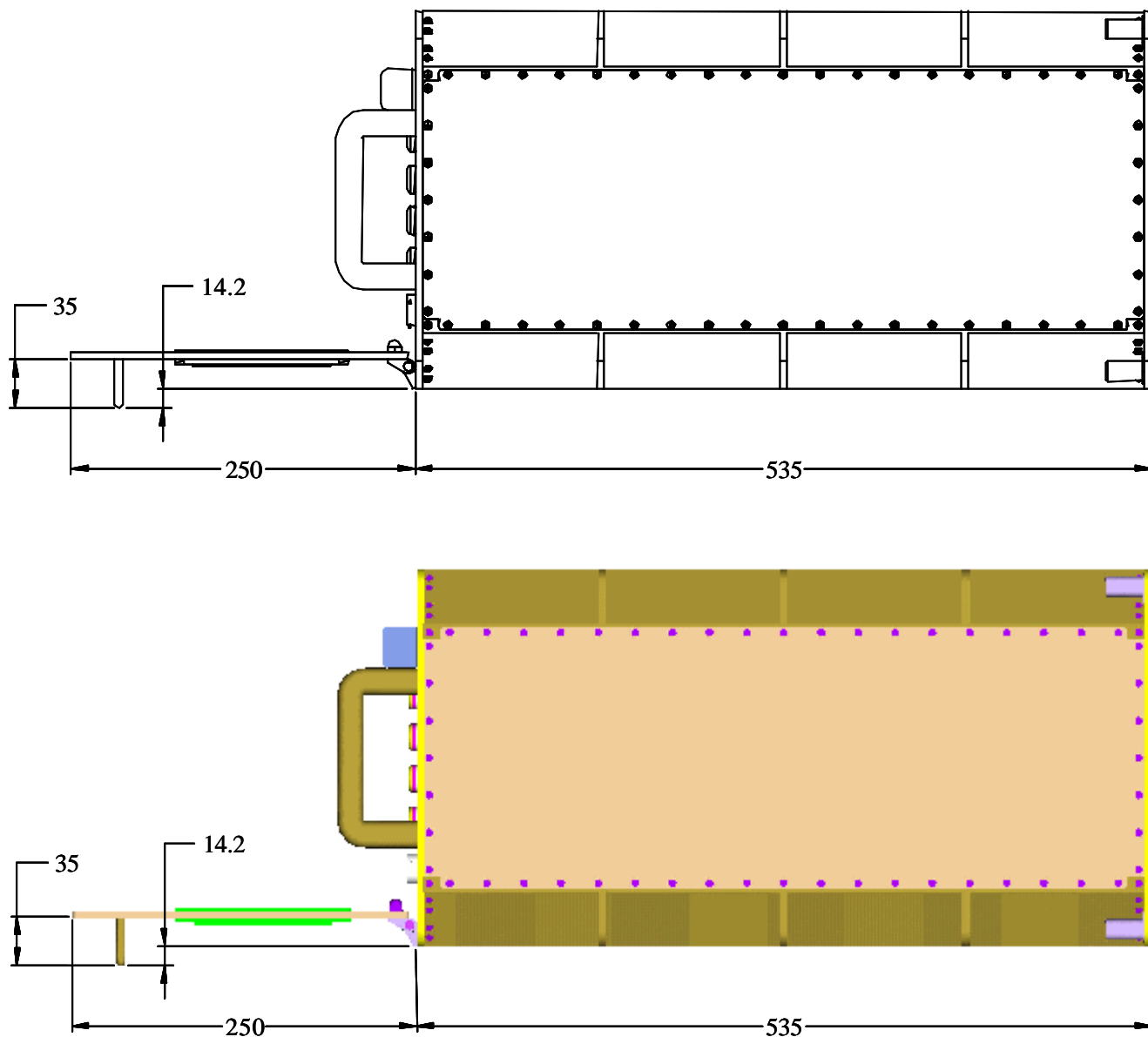


Figure 6-7 Side View of ACOP with the Front Panel Open (dimensions)

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## 6.3 ACOP SOFTWARE INTERFACES

### 6.3.1 ACOP / AMS-02 DATA INTERFACE

All AMS-02 data communicated externally is transmitted and received as AMS Frames of data. Each AMS Frame begins with a set of CCSDS and AMS headers. The CCSDS system has two headers, a required primary header and an optional (but required by ISS in most cases) secondary header. AMS-02 attaches a required AMS Primary Frame Header after the CCSDS header(s) and optionally an AMS Secondary Frame Header.

The CCSDS headers and AMS-02 data are organized in terms of 16-bit words. The following Figure 6-8 introduces the various values within the AMS Frame headers.

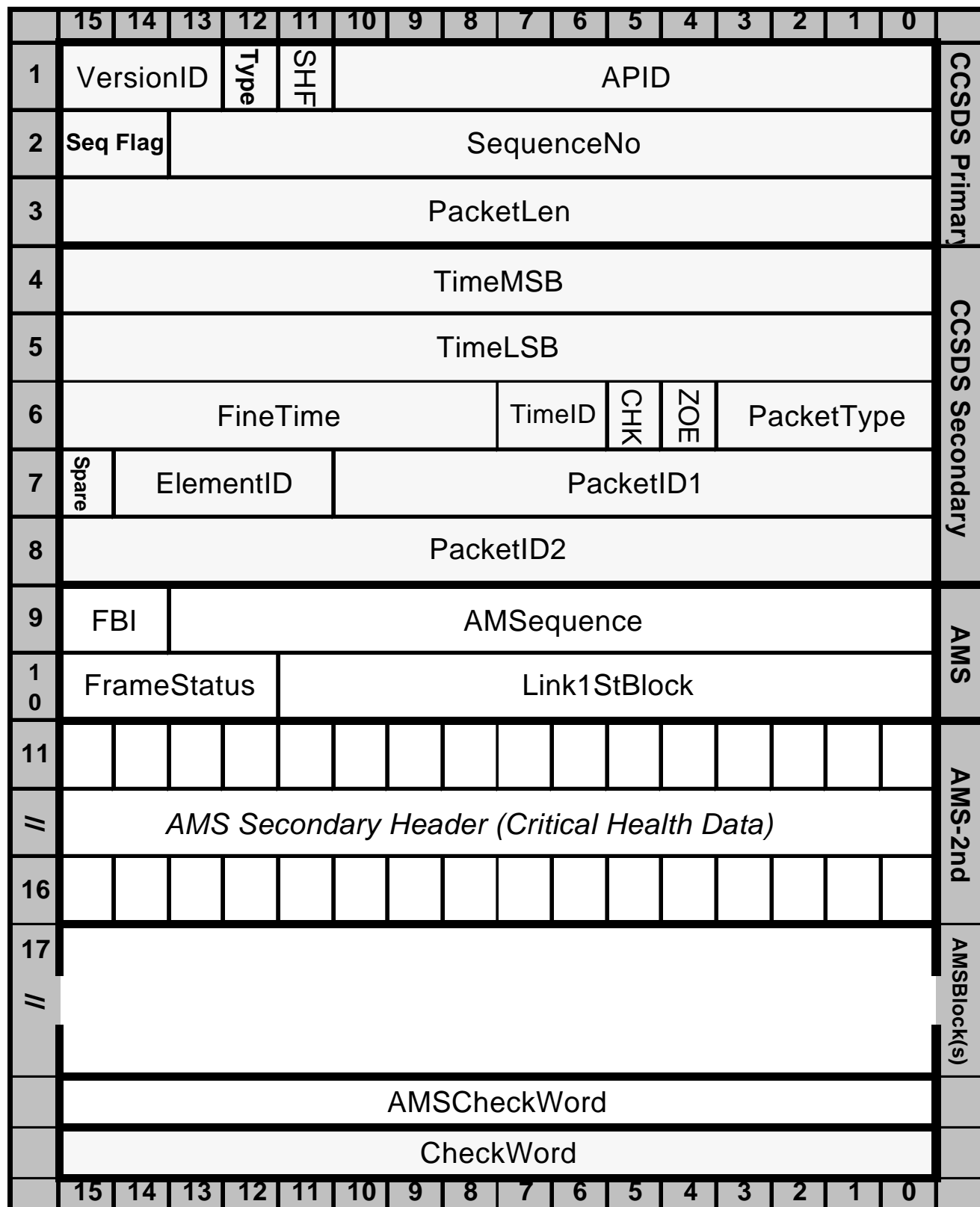


Figure 6-8 AMS Frame of data

### 6.3.1.1 DEFINITION OF FIELDS IN HEADERS

These tables define the valid values, the values AMS-02 utilizes, and comments on the purpose of each field.

#### 6.3.1.1.1 CCSDS PRIMARY HEADER

Item	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
Location <sup>9</sup>				
<b>VersionID</b> 1.15.3	0	0 - Ignored.	0	Version number for CCSDS packet format (does not change)
<b>Type</b> 1.12.1	0: Core 1: Payload	1 - Ignored.	1	Distinguishes between core and payload packet types to extend the APID space to 4032
<b>SHF</b> 1.11.1	1: Present 0: Not present	1 - On receipt is honored.	1	Indicates whether, or not, a Secondary Header follows the primary header. Currently required (always set to 1). However, <b><u>AMS-02 supports this value being 0 or 1 on all interfaces</u></b>
<b>APID</b> 1.10.11	0 – 2031	As assigned by NASA  Frames received with invalid APIDs are an error and will be ignored	As assigned by NASA, usage as defined within this ICD.	Application Process ID. Used to determine the data path by NASA and the data stream by AMS-02.
<b>SeqFlag</b> 2.15.2	0b00: Continuation 0b01: First segment 0b10: Last segment 0b11: Un-segmented	0b11 - Ignored.	0b11	Must be 0b11 for KU system

<sup>9</sup> This area contains the word.start-bit.number-bits

Item	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
Location <sup>9</sup>				
<b>SequenceNo</b>  2.13.14	0 – 16383	Used for de-framing of frames received to detected number of lost or missing blocks.	For frames generated this is a sequence within each APID (stream).	Sequential count which numbers each packet on a Logical Data Path, i.e., a separate counter is maintained for each source-destination pair (APID)
<b>PacketLen</b>  3.15.16	0 – 65535	0 – 4084	0-4084	The length of the remainder of the CCSDS packet including CheckWord if present. The value is the number of bytes (octets) following this field minus 1.

Table 6-3 CCSDS Primary Header

## 6.3.1.1.2 CCSDS SECONDARY HEADER

Item Location <sup>10</sup>	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
<b>TimeMSB</b> 4.15.16	0 – 65535	Most significant 16 bits of time in seconds.	Most significant 16 bits of time in seconds.	The time value represents the elapsed time since midnight 5-6 January 1980. The least significant bit (LSB) of the least significant octet of coarse time is equal to 1 second.
<b>TimeLSB</b> 5.15.16	0 – 65535	Least significant 16 bits of time in seconds.	Least significant 16 bits of time in seconds	See above.
<b>FineTime</b> 6.15.8	0 – 255	Ignored	Best effort sub-second time of frame generation.	The LSB of this field is equal to 2 <sup>-8</sup> second or about 4 ms
<b>TimeID</b> 6.7.2	0b00: Time not used 0b01: Cmd auth or data 0b10: Time tag cmd 0b11: Not used	0b01 - Ignored.	0b01	The time field is always present. This field indicates its use. For Data Packets, the field is always 0b01 and the time fields contain the time at the beginning of the processing frame when the packet was generated. Other values are for command processing, unused by AMS.
<b>CHK</b> 6.5.1	0: Not present 1: Present  See comments.	1 - If present in received frames the last word of the frame is not considered to be AMS data. It must be checked.  Commands with invalid check words are ignored.	0	This field indicates if a CheckWord (16-bit add without carry checksum) is contained in the CCSDS packet. When present, the CheckWord is the last 16-bit word of the packet. All commands must contain a CheckWord. Data packets do not require a CheckWord.

<sup>10</sup> This area contains the word.start-bit.number-bits

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Item	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
Location <sup>10</sup>				
<b>ZOE</b> 6.4.1	0: Frame from onboard ZOE recording 1: All others	0 - Ignored.	0	Used in a telemetry data packet to indicate that the telemetry packet is from the onboard ZOE recording (HCOR, etc).
<b>PacketType</b> 6.3.4	0b0001: Data dump 0b0100: Telemetry 0b0110: Private Sci 0b0111: Ancillary 0b1000: Ess Cmd 0b1001: Sys Cmd 0b1010: RT/PL Cmd 0b1011: Data Load	0b1010 - Ignored for frames received (all frames received are treated as commands).	0b0110	Used to distinguish type of packet for data packets and command packets.
<b>Spare</b> 7.15.1		Ignore	0	Not used.  Note: Since AMS has no requirement for HOSC processing of science data telemetry, Per SSP57002C, all of word 7 is available to the payload use.
<b>ElementID</b> 7.14.4	0b0000: NASA 0b0001: NASA 0b0100: RSA 0b0101: CSA 0b0010: ESA/APM 0b0110: ESAATV 0b0011: NASDA 0b0111: ASI 0b1000: ESA/ERA <del>0b1001: NASA ISPR</del> 0b1010: SPP	0b0001 – Commands (Ignored).	0	Packet ID is Element-dependent, as defined by these 4 bits. The remaining 27 bits will be parsed into additional fields to support command-processing functions. It identifies the agency responsible for packet definition.

Item	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
Location <sup>10</sup>				
	0b1011: HTV 0b1100-0b1111: Spare			
<b>PacketID1</b> 7.10.11	Per SSP41175-02 Table 3.3.2.1.1-4	Ignored.	0x1111	This value depends on the ElementID field.
<b>PacketID2</b> 8.15.16	Per SSP41175-02 Table 3.3.2.1.1-4	Ignored.	0x2222  Note: Per SSP57002C this is Data Cycle Counter.	This value depends on the ElementID field.

Table 6-4 CCSDS Secondary Header

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### 6.3.1.1.3 AMS FRAME HEADERS AND FRAME CHECKSUMS

Item	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
Location <sup>11</sup>				
<b>FBI</b> 9.15.2	0	N/A	0	Reserved for future brilliant invention. <u>This word appears only as noted below.</u>
<b>AMSequence</b> <sup>12</sup> 9.15.4	0 – 16383	In streams where it appears it is used to reconstitute the CCSDS SequenceNo field.	For streams where it appears frames are generated with this as a copy of SequenceNo	Equivalent to the CCSDS sequence number
<b>FrameStatus</b> 10.11.12	Bit Mask. 0b1xxx: Randomize 0bx1xx: CRC 0bxx1x: EXTCMD 0bxxx1: AMSSHf	Logical OR of valid values as appropriate	Logical OR of valid values as appropriate	<u>Randomize</u> – This frame has been pseudo-randomized for STS KU transmission. <u>CRC</u> – This frame has a CRC placed at the end, similar to NASA check word. <u>EXTCMD</u> – A command frame from an organization external to the AMS-POCC (MSFC, JSC, Timeliner, ISS Crew, ...) <u>AMSSHf</u> – AMS Secondary Header Flag. If present the frame has a 10 byte AMS Secondary Header (CHD).
<b>Link1StBlock</b> 10.11.12	0xFFFF: Fill frame 0xFFE: No block starts 0–0xFFD: Pointer	As appropriate.	As appropriate	16-bit word offset to the first AMS Block in the frame. It is possible that no block starts in the frame in which case this pointer is 0xFFE. If the frame is a fill frame to be ignored the value is 0xFFFF. The pointer is relative to the first 16-bit word after Link1StBlock. The value 0x0 means the

<sup>11</sup> This area contains the word.start-bit.number-bits

<sup>12</sup> This word appears only in H&S data via PLMDM and ground commands. For these paths the CCSDS header is not in our control.

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Item	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
Location <sup>11</sup>				first 16-bit word after the headers is the AMSBlock ByteCount.
<b>AMS 2<sup>nd</sup>ary header</b> 11.15.80	See section 6.3.3.2 , Critical Health Data Format			The AMS-02 2 <sup>nd</sup> ary header is the Critical Health Data.
<b>AMS Block(s)</b>		Segmented variable length data blocks, decommutatable by AMS only.	Segmented variable length data blocks, decommutatable by AMS only	Segmented variable length data blocks, decommutatable by AMS only
<b>AMSCheckWord</b>	0 - 65535			AMS CRC value if FrameStatus has CRC bit set. This is the last two bytes of AMS data within a CCSDS packet. Note: AMSCheckWord and CheckWord are not mutually exclusive.
<b>CheckWord</b>	0 - 65535	All commands have CheckWords computed and verified. Commands with invalid CheckWords are ignored.	For payload-to-payload commands this value is required.	<p>“16-bit add without carry” check word. When present, the CheckWord is the last 16-bit word of the CCSDS packet.</p> <p>The CheckWord is a 16-bit add without overflow carry over the entire packet (except the CheckWord position). (SSP 50184 (draft) 1-Aug-2000).</p>

Table 6-5 AMS Frame Headers And Frame Checksums



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### 6.3.2 APID UTILIZATION

AMS-02 Data is logically organized as streams of data. Which data stream a particular AMS Frame belongs to is recognized by the APID of its CCSDS header<sup>13</sup>. The following table lists all the APID values used to define streams in the AMS-02 system.

Symbolic APID	Stream Represented	Interface	Assigned Value	Stream Handle
AMSCMD	Ground commands to AMS-02	OIU & LRDL (1553)	See below	0
AMSHK <sup>14</sup>	AMS-02 housekeeping data plus AMSCMD replies	OIU & LRDL (1553)	0x36C (876)	1
AMSSCI	AMS-02 science data	HRDL STS-RS422	0x3D0 (976)	2
AMSHKH	AMS-02 housekeeping data plus AMSCMD replies	HRDL STS-RS422	0x3D1 (977)	3
PBCKSCI	Playback of recorded AMSSCI	HRDL	0x3D2 (978)	4
PBCKHKH	Playback of recorded AMSHKH	HRDL	0x3D3 (979)	5
PTOPCMD <sup>15</sup>	Payload to payload command	HRDL	0x3D4 (980)	6
PTOPREPLY <sup>16</sup>	Payload to payload replies	HRDL	0x3D5 (981)	7
ACOPCMD	Ground commands to ACOP	RIC-LAN	See below	8
ACOPHK	ACOP housekeeping data plus ACOPCMD replies	RIC-LAN	0x36C (876)	9
ACOPQC	ACOP QC sampling of AMSSCI	MRDL	0x3CF (975)	10
SPARE1	Spare		0x3D7 (983)	N/A
AMSFILL	NASA defined fill frame APID – 0x7FF	STS-RS422	0x7FF	N/A

Table 6-6 APID Symbolic Values

ISS Command APIDs (used on S-band) are controlled and defined by the Core ICD and are documented in SSP 50539. APIDs are defined specific to a particular pair of physical locations. The following defines the APIDs for ACOP commands:

19 - MCC-H to ACOP in ER4 (LAB1P2)  
 119 - POIC to ACOP in ER4 (LAB1P2)  
 219 - PCS/P1 to ACOP in ER4 (LAB1P2)

<sup>13</sup> The exceptions to this are the AMSHK and ACOPHK streams. The ISS systems strip the CCSDS header from this data. These streams are identified during ground processing by their source.

<sup>14</sup> PIRN 52050-NA-0032 discusses that APID 0 is available for use by Payloads in health & status and file transfer packets. Its use is not mandatory

<sup>15</sup> While this is a private payload-to-payload stream one side of each direction of the conversation on this APID will appear in downlink data due to the nature of the APS tee function.

<sup>16</sup> See note above

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319 - PCS/P2 to ACOP in ER4 (LAB1P2)  
419 - PCS/P3 to ACOP in ER4 (LAB1P2)  
519 - PCS/P4 to ACOP in ER4 (LAB1P2)  
619 - PCS/P5 to ACOP in ER4 (LAB1P2)

21 - MCC-H to ACOP in ER3 (LAB1P4)  
119 - POIC to ACOP in ER3 (LAB1P4)  
219 - PCS/P1 to ACOP in ER3 (LAB1P4)  
319 - PCS/P2 to ACOP in ER3 (LAB1P4)  
419 - PCS/P3 to ACOP in ER3 (LAB1P4)  
519 - PCS/P4 to ACOP in ER3 (LAB1P4)  
619 - PCS/P5 to ACOP in ER3 (LAB1P4)

The ISS program has assigned the following values to AMS-02:

APIDs: 974-983  
SSIDs: 308-309

SSIDs are SubSet IDs. These are used to identify the health and status packets of payloads much as APIDs are used to identify telemetry packets.

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### 6.3.3 WORD SIZE, ALIGNMENT AND ORDERING

#### 6.3.3.1 WORD AND BYTE ORDERING

##### 6.3.3.1.1 FOR TELEMETRY FROM AMS-02 AND ACOP

The following rules apply to the word and byte order of the data:

1. For parameters which are larger than one byte (8-bits) the most significant byte (MSB) shall be transmitted first, followed by the next most significant byte and so forth until the least significant byte (LSB) is the last byte transmitted.
2. The transmission order of the bytes (contiguous 8 bit groups) and bits within each word shall be most significant followed by least significant.

This ordering is commonly called Big Endian (or Motorola formatting).

##### 6.3.3.1.2 FOR GROUND COMMANDS TO AMS-02 AND ACOP

For commands sent from the ground segments to AMS-02, the data ordering shall be the same as section 6.3.3.1.1 (Big Endian).

##### 6.3.3.1.3 FOR PAYLOAD TO PAYLOAD (AMS-02, ACOP, DDRS2) COMMANDS

For commands sent among the AMS-02 payloads, the data ordering shall be the same as section 6.3.3.1.1 (Big Endian).

##### 6.3.3.1.4 FOR COMMANDS FROM PLMDM AND PCS TO AMS-02 AND ACOP

For commands from PLMDM and PCS to AMS-02 and ACOP the data ordering shall be the same as section 6.3.3.1.1 (Big Endian).

### 6.3.3.2 CRITICAL HEALTH DATA (CHD) FORMAT

The Critical Health Data consists of ten bytes. During ISS operations this data shall be present in the 1553 data presented to the PLMDM as house keeping data. The frame status byte AMSSHF will indicate its existence in the frame. When Critical Health Data is present the AMS Block data starts ten bytes later in the frame.

Most of the format of the CHD is defined to accommodate the display of the data on the NASA POIC, HOSC, and SSCC display systems. This should allow a common nomenclature to exist between AMS-02 and NASA. In the table below the "Field Mnemonic" and "State Code" values should be displayed on NASA screens. The NASA PDL convention of byte numbers starting at 1 and bit numbers starting at 0 has unfortunately been preserved.

**Note:** The following definition of CHD will serve to support early testing of the system design. As operational knowledge is gained the CHD will be tuned to better support the system operation.

	0	1	2	3	4	5	6	7	
1	HEARTBEAT								1
2	CMD_COUNT								2
3	POWERSTEP			BUS_A	BUS_B	WATTS			3
4	MAGNET_STATE			UPS_A	UPS_B	CRYO_COOLER			4
5	MCT_OWNER		HRDL_OWNER		LRDL_OWNER		DAQ_OWNER		5
6	VEHICLE	HRDL_ACTIVE	LRDL_ACTIVE	DAQ_ACTIVE	DAQ_BUFFER			TAXI_ERRORS	6
7	TEMP_O_ALARM		TEMP_O_WARN		TEMP_U_ALARM		TEMP_U_WARN		7
8	TRD_GAS				MAG_GAS				8
9	TDM								9
10									10
	0	1	2	3	4	5	6	7	

Figure 6-9 Critical Health Data Layout



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Byte #	Start Bit #	# Bits	Field Mnemonic	Comments	Values		
1	0	8	HEARTBEAT	Rolling count of HK frames to this stream.	0-255		
2	0	8	CMD_COUNT	Rolling count of valid command frames received from all sources (ground, ACOP, ...)	0-255		
3	0	3	POWERSTEP	AMS-02 Power step on a best guess estimation by looking at PDB switches	Value	State Code	Comment
					0	UNDEF	In transition
					1	STEP-1	
					2	STEP-2	
					3	STEP-3	
					4	STEP-4	
					5	STEP-2A	Magnet charging
					6	STEP-3A	Tracker thermal
					7	STEP-4A	TBD
3	3	1	BUS_A	ISS Power feed A state	Value	State Code	Comment
					0	OFF	Not powered
					1	ON	Powered by ISS
3	4	1	BUS_B	ISS Power feed B state	Value	State Code	Comment
					0	OFF	Not powered
					1	ON	Powered by ISS
3	5	3	WATTS	Watts in 300w granularity	Value	State Code	Comment
					0	300W	0-299 watts
					1	600W	300-599 watts
					2	900W	600-899 watts
					3	1200W	900-1199 watts
					4	1500W	1200-1499 watts
					5	1800W	1500-1799 watts
					6	2100W	1800-2099 watts
					7	2400W	2100 + watts
4	0	3	MAGNET_STATE		Value	State Code	Comment
					0	NOT_AVAIL	Not available
					1	CHARGING	Charging
					2	RAMPDOWN	
					3	NORMAL	
					4	QUENCH	
					5	0x05	Not assigned
					6	0x06	Not assigned
					7	0x07	Not assigned
4	3	1	UPS_A	Status of UPS A  (not valid if MAGNET_STATE == NOT_AVAIL)	Value	State Code	Comment
					0	NOK	Battery NOT OK
					1	OK	Battery OK



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Byte #	Start Bit #	# Bits	Field Mnemonic	Comments	Values		
4	4	1	UPS_B	Status of UPS B  (not valid if MAGNET_STATE == NOT_AVAIL)	<b>Value</b>	<b>State Code</b>	<b>Comment</b>
					0	NOK	Battery NOT OK
					1	OK	Battery OK
4	5	3	CRYO_COOLER	Cryo-cooler status	<b>Value</b>	<b>State Code</b>	<b>Comment</b>
					0	NOT_AVAIL	Status not available
					1	1_FAILED	One unit failed
					2	2_FAILED	Two units failed
					3	3_FAILED	Three units failed
					4	4_FAILED	All units failed
					5	OK	Units OK
					6	0x06	Not assigned
					7	0x07	Not assigned
5	0	2	MCT_OWNER	JMDC that owns the main control computer task	0-3		
5	2	2	HRDL_OWNER	JMDC that owns the HRDL link	0-3		
5	4	2	1553_OWNER	JMDC that owns the 1553 link	0-3		
5	6	2	DAQ_OWNER	JMDC that owns the DAQ task	0-3		
6	0	1	VEHICLE	ISS or STS mode	<b>Value</b>	<b>State Code</b>	<b>Comment</b>
					0	STS	On STS
					1	ISS	On ISS
6	1	1	HRDL_ACTIVE	HRDL (or RS422) transfer active. Indicates Tx light is on.	<b>Value</b>	<b>State Code</b>	<b>Comment</b>
					0	NO	
					1	YES	
6	2	1	LRDL_ACTIVE	LRDL health and status transfer active	<b>Value</b>	<b>State Code</b>	<b>Comment</b>
					0	NO	
					1	YES	
6	3	1	DAQ_ACTIVE	DAQ task is active	<b>Value</b>	<b>State Code</b>	<b>Comment</b>
					0	NO	
					1	YES	
6	4	3	DAQ_BUFFER	Per cent of buffer full	<b>Value</b>	<b>State Code</b>	<b>Comment</b>
					0	NO_DATA	No data
					1	0%	0 to 24%
					2	25%	25 to 49%
					3	50%	50 to 74%
					4	75%	75 to 84%
					5	85%	85 to 94%
					6	95%	95 to less then 100%
					7	FULL	No room left

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Byte #	Start Bit #	# Bits	Field Mnemonic	Comments	Values		
6	7	1	TAXI_ERRORS	HRDL health flag to detect APS induced errors on HRDL. Used by POIC after APS switching. This value is set on error and cleared once CHD is sent.	Value	State Code	Comment
					1	ERROR	There have been recent errors
					0	NONE	No recent errors
	0	2	TEMP_O_ALARM	Number of sensors in over temp alarm	Value	State Code	Comment
					0	NONE	
					1	1	
					2	2	
7	2	2	TEMP_O_WARN	Number of sensors in over temp warning	3	3+	Three or more
					Value	State Code	Comment
					0	NONE	
					1	1	
7	4	2	TEMP_U_ALARM	Number of sensors in under temp alarm	2	2	
					3	3+	Three or more
					Value	State Code	Comment
					0	NONE	
7	6	2	TEMP_U_WARN	Number of sensors in under temp warning	1	1	
					2	2	
					3	3+	Three or more
					Value	State Code	Comment
8	0	4	TRD_GAS	Status of TRD gas systems	0-16		
8	4	4	MAG_GAS	Status of Magnet gases (warm and cold)	0-16		
9	0	16	TDM	See below.	0-65535 – No decom by NASA		

Table 6-7 Critical Health Data Format

#### 6.3.3.2.1 TIME DIVISION MULTIPLEX (TDM) VALUES

Time division is used to significantly expand the number of data bytes available to AMS for status monitoring in the event of a KU outage. TDM values are spread out over the HEARTBEAT determined, 256-message cycle (just over 4 minutes).

The TDM values are placed into a table using an indirection table that supports multiple occurrences of any given TDM values per 256-message cycle. This allows more import values to update more often the once per 4 minutes. The HEARTBEAT value is used to index into the 256-byte entry indirection table and obtain the 16-bit word index of the TDM table defined below.

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Notes:

1. Lost or missing health and status packets will result in stale data entries in the TDM table.
2. The TDM tables are not required to be de-multiplexed (de-commutated) by NASA.

The following table just serves as a placeholder until we develop the values we would like to monitor.

Suggested things:

- Last command (bottom 8-bits of DataType from last AMSBlock)
- Event count
- Error counts
- Thermal details
- Gas details
- Gas pressure deltas – Not avail, steady, increasing, decreasing
- USCM status map – active/not (responds on CAN)
- PDB switch map
- JPD switch map
- Crate heater status
- Tracker thermal control details

Word #	Start Bit #	# Bits	Field Mnemonic	Comments	Values
1	0	8	VAL1	First TDM value	0-255
1	8	8	VAL2	Second TDM value	0-255
2	0	16	VAL3	Third TDM value	0-65535

*Table 6-8 TDM Field Values*

### 6.3.3.2.2 TDM INDIRECTION TABLE

This sample table shows how the two entries above repeat in the data.

HEART BEAT	TDM Word #	HEART BEAT	TDM Word #	HEART BEAT	TDM Word #	HEART BEAT	TDM Word #
0	1	64		128		192	
1	2	65		129		193	
2	1	66		130		194	
3	2	67		131		195	
4		68		132		196	
5		69		133		197	
6		70		134		198	
7		71		135		199	
8		72		136		200	
9		73		137		201	
10		74		138		202	
11		75		139		203	
12		76		140		204	
13		77		141		205	
14		78		142		206	
15		79		143		207	
16		80		144		208	
17		81		145		209	



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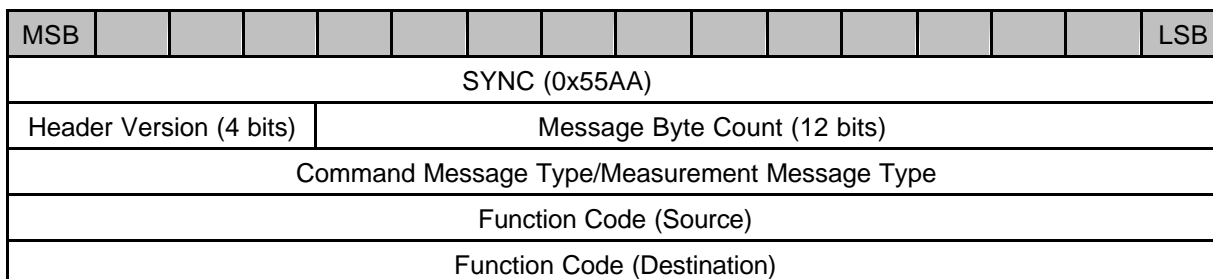
HEART BEAT	TDM Word #	HEART BEAT	TDM Word #	HEART BEAT	TDM Word #	HEART BEAT	TDM Word #
18		82		146		210	
19		83		147		211	
20		84		148		212	
21		85		149		213	
22		86		150		214	
23		87		151		215	
24		88		152		216	
25		89		153		217	
26		90		154		218	
27		91		155		219	
28		92		156		220	
29		93		157		221	
30		94		158		222	
31		95		159		223	
32		96		160		224	
33		97		161		225	
34		98		162		226	
35		99		163		227	
36		100		164		228	
37		101		165		229	
38		102		166		230	
39		103		167		231	
40		104		168		232	
41		105		169		233	
42		106		170		234	
43		107		171		235	
44		108		172		236	
45		109		173		237	
46		110		174		238	
47		111		175		239	
48		112		176		240	
49		113		177		241	
50		114		178		242	
51		115		179		243	
52		116		180		244	
53		117		181		245	
54		118		182		246	
55		119		183		247	
56		120		184		248	
57		121		185		249	
58		122		186		250	
59		123		187		251	
60		124		188		252	
61		125		189		253	
62		126		190		254	
63		127		191		255	

Table 6-9 TDM Indirection Table



### 6.3.3.5 EXPRESS SYNC AND HEADER

Messages between the RIC ACOP are in EXPRESS packet format with sync word (55AA) and EXPRESS Header. When the RIC forwards each message to the desired destination, the EXPRESS Header will be kept, except the RIC will remove the EXPRESS Header from the Health and Status data before sending it to the PL MDM.



SYNC	0x55AA
Header Version	0b0000
Message Byte Count	Total Remaining Bytes in associated message, excluding Serial Checksum Words where applicable
Command Msg Type	See table below for "TYPE"
Source Function Code	<ul style="list-style-type: none"> <li>ACOP is assigned a unique function code (0x0010 to 0xFFFE).</li> <li>The RIC is function code 0x0001.</li> <li>The ground station is 0x000F.</li> <li>Rack broadcast is 0xFFFF.</li> </ul>
Destination Function Code	See above

Figure 6-11 EXPRESS Header



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DESCRIPTION	SOURCE	DESTINATION	FREQUENCY	TYPE
Ground Station Command	RIC	PLD	Async	0x0100 – 0xFFFF
Payload Health and Status	PLD	RIC	1 Hz	0x009B
PEP Bundle Request	PLD	RIC	Async	0x0049
PEP Procedure Execution Request	PLD	RIC	Async	0x004C
Rack Time Request	PLD	RIC	Async	0x004D
Ancillary Data Config Control	PLD	RIC	Async	0x0020
Payload Telemetry Downlink Data	PLD	RIC	Async	0x009C
EMU File Transfer Request	PLD	RIC	Async	0x0041
PLD File Transfer Data Block	PLD	RIC	Async	0x00A4
PLD File Transfer Request	PLD	RIC	Async	0x0042
Ancillary Data Set	RIC	PLD	Async, .1, 1 Hz	0x0098
Broadcast Ancillary Data Packet	RIC	PLD	10 Hz	0x0099
Rack Request Response	RIC	PLD	Async	0x0082
Rack Time Response	RIC	PLD	Async	0x0080
EMU File Transfer Request	RIC	PLD	Async	Ethernet
PLD File Transfer Request	RIC	PLD	Async	0x0042
PLD File Transfer Data Block	RIC	PLD	Async	0x00A4

Table 6-10 EXPRESS Header Message Types

### 6.3.3.6 ACOP COMMANDING

The following figure shows the format of commands sent to ACOP:

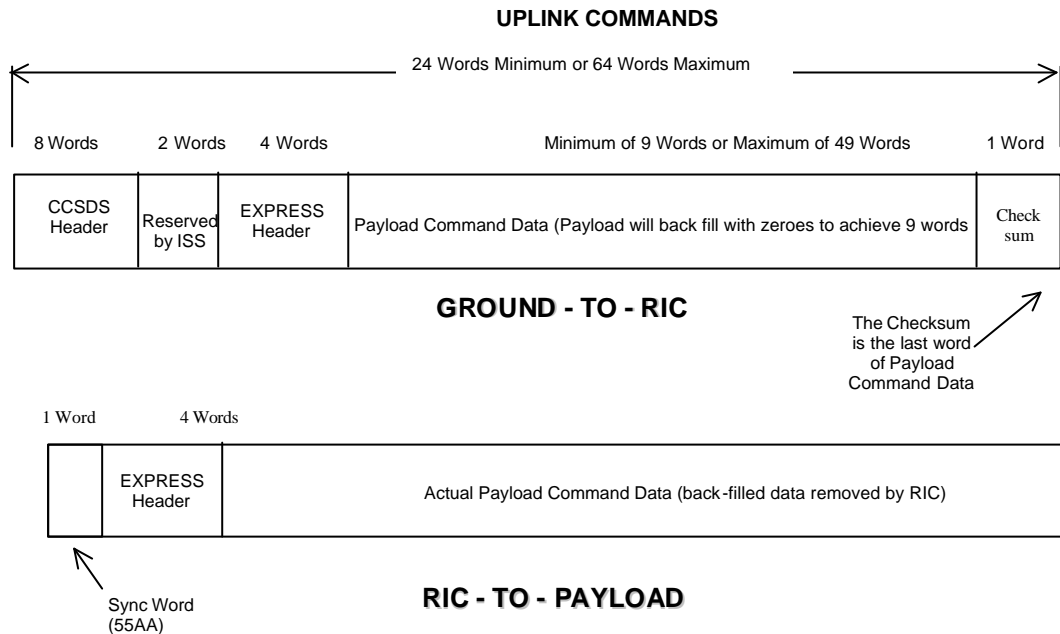


Figure 6-12 Ground to RIC and RIC to ACOP Command Layout

The payload command data words in PDL include the EXPRESS Header and the payload command data words, but not the sync word.

The RIC receives the command from 1553, compares the actual received number of words with the CCSDS packet length in Word 3, and checks the CCSDS checksum word. The RIC uses the length in the CCSDS header for verifying the received command length and uses the "Message Byte Count" in the first word of the EXPRESS Header for verifying the actual number of payload command byte(s).

After the verification process the RIC issues the payload command to the destination Function Code. The RIC removes the CCSDS header, fill words, and checksum. The contents of the command message received by the payload will be the sync word at the beginning of the packet, EXPRESS Header, and the payload command data words.

For an RS-422 payload the RIC will add the serial checksum word at the end of the message before sending it out to the payload. The sync word added by the RIC is not part of the command message. The Message Type is not used by the RIC and can be used by the payload for its own purpose as long as the contents are between 0100 to FFFE.

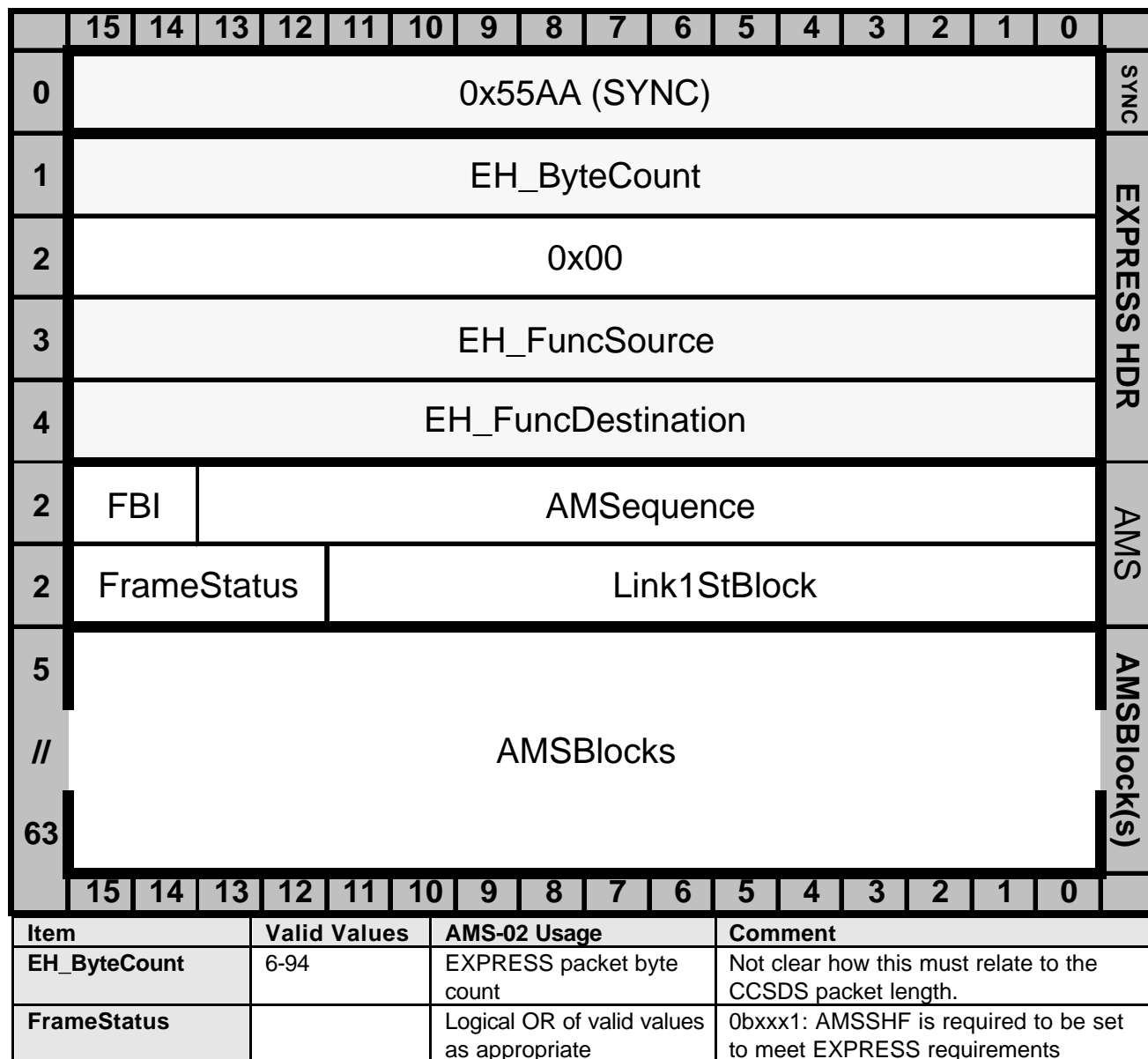


Figure 6-13 EXPRESS Command Envelop

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### 6.3.3.7 ACOP HEALTH AND STATUS DATA

ACOP provides Health and Status (including Safety) data to the RIC at a rate of 1.0 Hz, continuously, while ACOP is powered on. The Health and Status data has a fixed length of 92 16-bit words (including Emergency, Caution, and Warning (ECW) word). The sync word, the 4 words of EXPRESS Header, and any RS-422 serial checksum word are not counted as part of the 92 words.

The first word of Health and Status data is reserved by ACOP as the ECW word. ACOP uses parameter monitoring as the primary means of fire detection and sets the ECW word to indicate potential for fire. The integer 1 (Advisory) will be located at the most right bit (last transmit bit) in the 16-bit word.

ACOP provides as the second word of Health and Status data a H&S Cycle Counter. The H&S Cycle Counter shall be an unsigned 16 bit integer in the range of zero to 65,535. The H&S Cycle Counter shall be set to zero for the first H&S packet that the payload transmits. The H&S Cycle Counter shall be incremented by a value of one for each H&S packet transmitted. Once a value of 65,535 is reached, the H&S Cycle Counter for the following packet shall be reset to a value of zero and then the payload will continue incrementing the H&S Cycle Counter as noted above. This H&S Cycle Counter will be used by payload operations personnel to determine whether H&S data being received is stale.

The RIC receives ACOP's Health and Status data and verifies the correct EXPRESS Header with message type as 009Bh. After the verification process the RIC removes the sync word, EXPRESS Header, and serial checksum word (RS-422 payload only) and adds the Subset ID, Service Request Word, and Service Request Data for each payload.

The RIC combines all active payload Health and Status data in the order in which it is received and EXPRESS Subsystem Health and Status data as oneEXPRESS Rack Health and Status message sent to the PL MDM at 1-Hz rate. The Subset ID word is always needed and the spaces for the Service Request ID and Service Request data words are reserved (zero filled when no request is present from the payload).

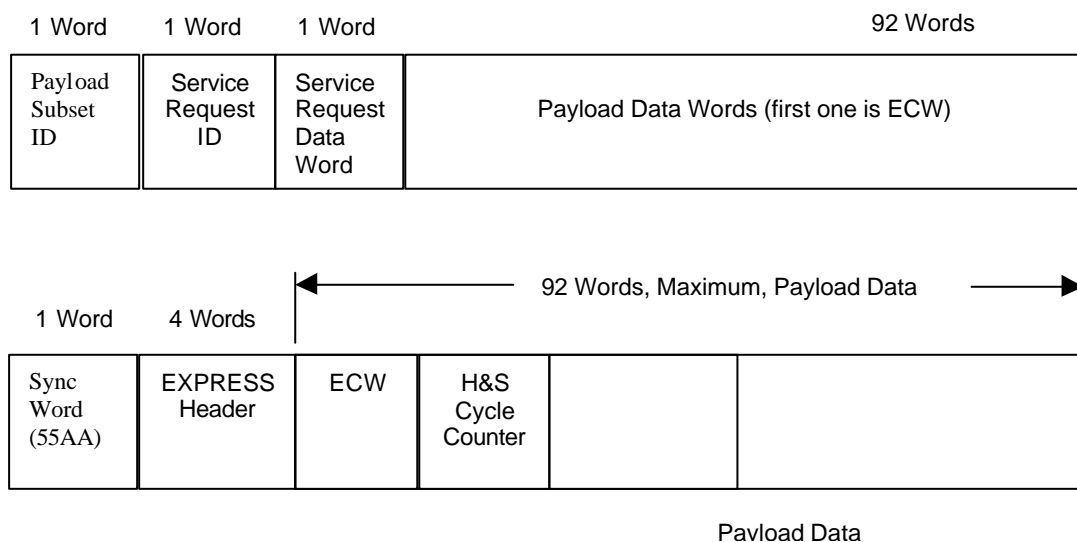


Figure 6-14 ACOP Health and Status Layout

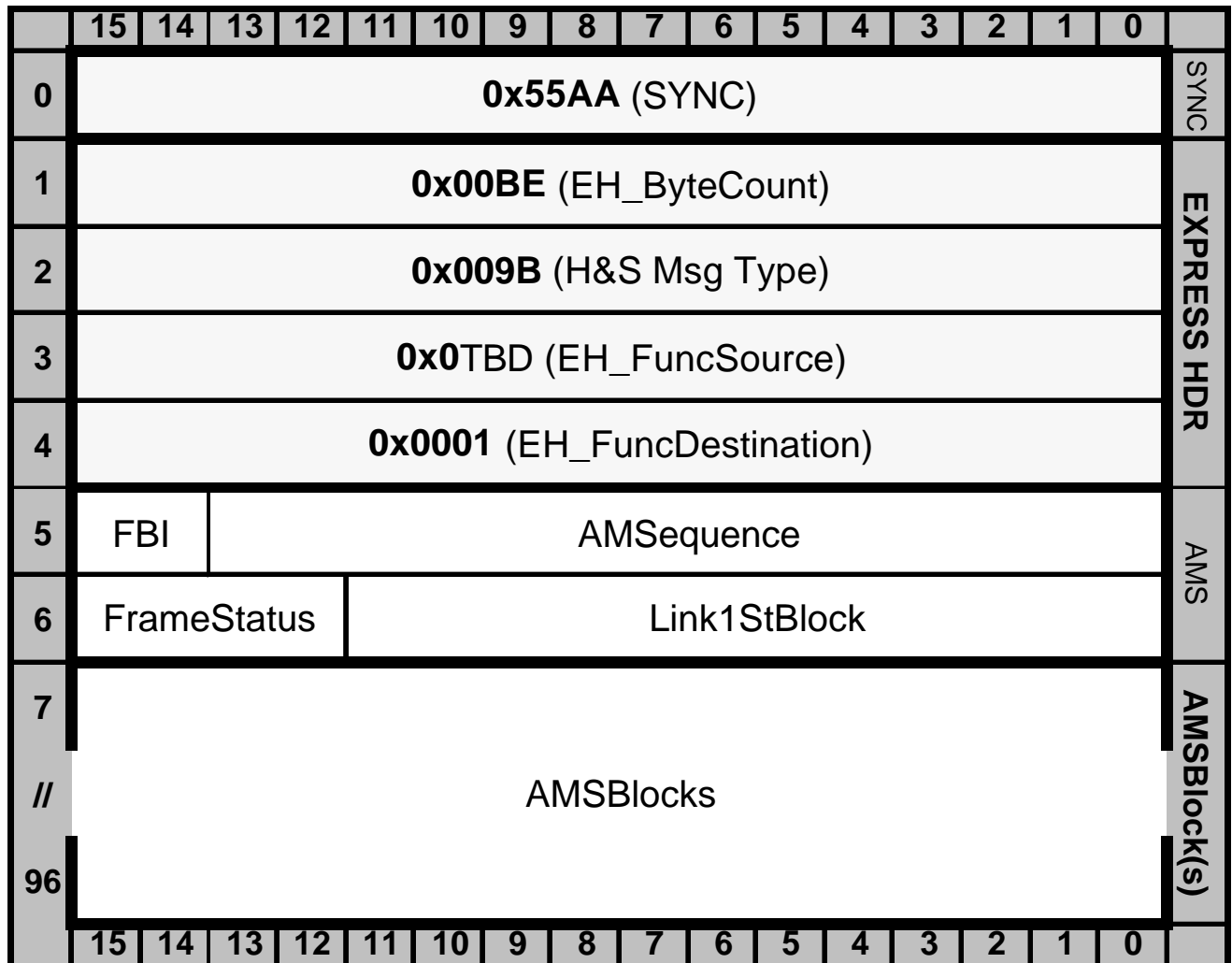


Figure 6-15 EXPRESS Health & Status Envelop

### 6.3.3.8 ACOP TIME SYNCHRONIZATION

ACOP requests the time from the RIC periodically using the following command:

MSB															LSB
SYNC (0x55AA)															
Header Version (0b0000)				Byte Count (0x0006)											
Message Type (0x004D)															
ACOP Function Code (0x0100)															
RIC Function Code (0x0001)															

Figure 6-16 ACOP Time Request

The RIC responds with:

MSB															LSB
SYNC (0x55AA)															
Header Version (0b0000)				Byte Count (0x0016)											
Message Type (0x0080)															
RIC Function Code (0x0001)															
ACOP Function Code (0x0100)															
CCSDS Preamble Field = '01010000'B								MSB of BCD Year Field (19-20)							
LSB OF BCD YEAR FIELD (0-99)								BCD Month Field (1-12)							
BCD Day of Month Field (1-31)								BCD Hour Field (0-23)							
BCD Minutes Field (0-59)								BCD Seconds Field (0-59)							
Spare - 000 h												Binary Sub-seconds high (0-15) <sup>1</sup>			
Binary Sub-seconds Low (0-65535) <sup>1</sup>															
Universal Time Coordinate (UTC) Time Conversion Parameter (0-65535)															
ALWAYS SET TO ZERO. NOTE THIS DATA IS CONTAINED IN BROADCAST ANCILLARY DATA															
Non-CCSDS Seconds/sub-seconds (0-65535)															
The one's portion of the seconds plus the sub-seconds information of the CCSDS time converted to a straight binary count rounded to the nearest 256 microsecond (LSB = 256 microsec)															
<sup>1</sup> Combining sub-second high and sub-second low, the total range is 0 - 1048560 at one microsecond per count.															

Figure 6-17 RIC Time Response

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### 6.3.3.9 ACOP / AMS-02 SOFTWARE INTERFACE - ISS AMS-02 HRDL UTILIZATION

AMS-02 has two prime targets for HRDL transfers. The first is the High Rate Frame Multiplexer (HRFM - via the High-Rate Communications Outage Recorder HCOR). The HRFM interleaves data to the KU-Band transmission system for downlink.

The second target is the AMS-02 Crew Operations Post (ACOP) which provides an onboard recording of AMS-02 data. The APS can be configured to tee data transmitted by AMS-02 to both the HRFM and ACOP.

Nominally there should be a dedicated (24x7x365x3) link for both transmit and receive between AMS-02 and ACOP. A link between ACOP and HRFM can be configured based upon program scheduling for AMS-02 downlink.

The AMS-02 HRDL link nominally carries the AMS-02 Science Data Stream and a second copy of AMS-02 House Keeping Data Stream.

#### 6.3.3.9.1 HRDL PROTOCOL AND FRAMING

AMS-02 utilizes the Consultative Committee for Space Data Systems (CCSDS) Packet protocol for all systems, including HRDL (The bit-stream protocol is not supported).

JIM-HRDL implements fixed size frames (per "session") of not more than 4095 bytes. In order to change its frame size JIM-HRDL must be reset and reconfigured, disrupting any activity on the HRDL link and starting a new "session".

#### 6.3.3.9.2 AMS-02 HRDL TRANSMISSIONS

AMS-02 only has a single HRDL transmit connection. The supported connections via the APS for this connection are:

- No connection
- Connection to ACOP
- Connection to HRFM for KU-Band transmission
- Connection to both HRFM for KU-Band transmission and to ACOP

This link carries the following data streams: AMSHK (a second copy), AMSSCI, ACOPCMD, and ACOPREPLY.

**Note:** Strictly speaking by ISS documents, an APID represents a single simplex point-to-point link. AMS-02 utilizes APIDs to delineate data streams.

The connection between AMS-02 and ACOP by HRDL represents a private payload-to-payload connection and as such is not governed by ISS requirements. On this link AMS-02 reuses the APIDs ACOPCMD and ACOPREPLY to provide a symmetrical link. However due to the APS tee function the ACOPCMD and ACOPREPLY streams will appear in ISS traffic to the KU-Band. Since the ISS program does not see the ACOP to AMS-02 traffic this should be fine.

#### 6.3.3.9.3 AMS-02 HRDL RECEPTION

AMS-02 has a single HRDL receiver connection. The supported connections via the APS for this connection are:

- No connection
- Connection to ACOP

This link carries the following data streams: ACOPREPLY, ACOPCMD

#### 6.3.3.9.4 AMS-02 HDRL DATA LAYOUT IMPLEMENTATION

Figure 6-18 documents the HRDL data layout.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	VersionID			Type	SHE	APID											CCSDS Primary
2	Seq Flag		SequenceNo														
3	PacketLen																
4	TimeMSB																CCSDS Secondary
5	TimeLSB																
6	FineTime							TimeID		CHK	ZOE	PacketType					
7	Spare	ElementID				PacketID1											
8	PacketID2																
9	FrameStatus				Link1StBlock												AMS
10																	AMS Biks
//																	
2042																	
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	

Figure 6-18 HRDL Data Layout Implementation